METRIC

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Note: The document identifier and heading has been changed on this page to reflect that this is a performance specification. There are no other changes to this document. The document identifier on subsequent pages has not been changed, but will be changed the next time this document is revised.

PERFORMANCE SPECIFICATION

Compressed ARC Digitized Raster Graphics (CADRG)

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification provides requirements for the preparation and use of the Raster Product Format (RPF) Compressed ARC Digitized Raster Graphics (CADRG) data. CADRG is a general purpose product, comprising computer-readable digital map and chart images. It supports various weapons, C3I theater battle management, mission planning, and digital moving map systems. CADRG data is derived directly from ADRG and other digital sources through downsampling, filtering, compression, and reformatting to the RPF Standard. CADRG files are physically formatted within a National Imagery Transmission Format (NITF) message.

1.2 Purpose. The purpose of this document is to specify the data format and characteristics of CADRG for producers and users.

1.3 Security.

1.3.1 Security classification of specification. This product specification is UNCLASSIFIED.

1.3.2 Security classification of product. Media containing CADRG data shall carry the highest classification and restrictions that are determined from the original source graphics.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, Defense Mapping Agency, ATTN: PR ST A-13, 8613 Lee Highway, Fairfax, VA 22031-2137 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A **AREA MCGT**

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the current Department of Defense Index of Specifications and Standards (DODISS) and the supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-A-89007 – Defense Mapping Agency, Military Specification: ARC Digitized Raster Graphics

STANDARDS

MILITARY

MIL-STD-2411 – Defense Mapping Agency, Military Standard, Raster Product Format (RPF)

MIL-STD-2411-1 – Defense Mapping Agency, Military Standard, Registered Data Values for Raster Product Format

MIL-STD-2411-2 - Defense Mapping Agency, Military Standard, Integration of Raster Product Format Files Into the National Imagery Transmission Format

MIL-STD-2500 – Military Standard, National Imagery Transmission Format (Version 2.0)

MIL-STD-600010 – Department of Defense, DMA Stock Number Bar Coding

MIL-STD-129 – Marking for Shipment and Storage

HANDBOOKS

MILITARY

MIL-HDBK-1300 – Military Handbook, National Imagery Transmission Format Standard (NITFS)

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2. Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

a. DMA Technical Manual, DMA TM 8358.1, Defense Mapping Agency: Datums, Ellipsoids, Grids, and Grid Reference Systems, First Edition.

b. DMA Technical Report, DMA TR 8350.2: World Geodetic System 84, 2d Edition.

c. DMA Technical Instruction, TI/2DJ/001, DMA Technical Instructions and Quality Requirements for Printing and Finishing of Jewel Case Liners & Information Booklets (Inserts) for Mapping, Charting and Geodetic (MC&G) Compact Disk Storage Media.

(Application for DMA TR, TM, and TI copies should be addressed to Defense Mapping Agency, ATTN: AM, ST A-2, 8613 Lee Highway, Fairfax, VA 22031-2137.)

d. STANAG 2211, Geoid Datums, Spheroids, Grids, and Cell References.

e. FAR, Federal Acquisition Regulation

(Copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

f. Map Projections—A Working Manual, U.S. Geological Survey Professional Paper 1395, First Edition, 1987

(Application for copies of USGS documents should be made to U.S. Geological Survey, 507 National Center, Reston, VA 22092.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are the most current issues listed in the DODISS. Unless otherwise specified, the issues of the following documents that are not listed in the DODISS are the issues of the documents as cited below.

a. ANSI/IEEE Std. 754-1985, IEEE Standard for Binary Floating Point Arithmetic.

b. ANSI/IEEE 1003.1, Portable Operating System Interface for Computer Environments (POSIX)

c. ISO/IEC DIS 10777-1990, 4 mm - Wide Magnetic Tape Cartridge for Information Interchange.

d. ISO/IEC DIS 11319-1991, 8 mm - Wide Magnetic Tape Cartridge for Information Interchange.

e. ISO 9660-1988, Information Processing - Volume and File Structure of CD-ROM for Information Interchange.

f. ISO/IEC DIS 10089, 130 mm Read-Writeable Optical Media Cartridge, Erasable Optical Disk (EOD)

g. ISO/IEC DIS 10139, Information Technology – Data Interchange on Read-Only 120 mm Optical Data Disks (CD-ROM)

h. ISO/IEC DIS 13346, Volume and File Structure of Write-Once and Rewriteable Media Using Nonsequential Recording (NSR) for Information Interchange

(Application for ANSI and ISO copies should be addressed to the American National Standards Institute (ANSI) Inc., 1430 Broadway, New York, NY. 10018.)

i. Southard, D. A., 1992, "Compression of Digitized Map Images," Computers and Geosciences, Vol. 18, No. 9, pp. 1213-1253.

j. Markuson, N. J., July 1994, "Analysis of Compression Techniques for Common Mapping Standard (CMS) Raster Data," ESC Technical Report, MTR-93B0000091.

(Application for MITRE Report copies should be addressed to The MITRE Corporation, 202 Burlington Road, Bedford, MA 01730-1420.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards) the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified (see 6.2), a sample shall be subjected to first article inspection (see 6.3) in accordance with 4.3.

3.2 Accuracy.

3.2.1 Accuracy. Vertical accuracy is the same as that of the original source (paper) graphics.

3.2.2 Accuracy.

a. The accuracy of CADRG is dependent upon the accuracy of the original map or chart from which source data for CADRG was derived. The quantization error attributable to downsampling from 100 microns (μ) in ADRG to 150 μ in CADRG, contributes only an insignificant error compared with the error inherent in the original source graphics.

b. The source ADRG data originate in or have been converted to the World Geodetic System 1984 (WGS-84) datum (see 3.3.2). If an ADRG image was converted to WGS-84 from another datum, then the latitude and longitude depicted on the ADRG images (and corresponding CADRG images) will generally no longer align with the latitude and longitude that the gridlines represent.

3.2.3 Radiometric fidelity. The red, green, and blue (RGB) pixels of the CADRG are representations of the colors in the source map or chart product. Color differences among maps and charts are not removed in the process of scanning the charts. The transformation process for CADRG emphasizes image contrast, clarity and legibility over exact color fidelity; most of the color loss should not be operationally significant. The ability of output systems (e.g., printers and displays) to faithfully reproduce colors from CADRG data depends on the resolution and color integrity of the output systems.

3.3 Datum.

3.3.1 Vertical datum. The vertical datum for CADRG is the same as the vertical datum of the source ADRG data and its source graphics.

3.3.2 Horizontal datum. The horizontal datum for CADRG shall be WGS-84, as defined by DMA TM 8358.1.

3.4 Product description. The CADRG product shall conform to MIL-STD-2411. It normally will be produced directly from source maps of all scales by processing (see 3.10) and reformatting into a CADRG frame file structure (see 3.12). Miscellaneous scale maps and charts or non-DMA maps may be the source for CADRG production. The processing includes spatial reduction (pixel downsampling) with filtering, vector quantization image compression, and color quantization.

To permit direct use by aircraft cockpit displays, CADRG data is arranged in frames and subframes with constant pixel sizes, and overlaps (see 3.5.4) that are consistent with limited memory and processing capabilities of avionics computers.

3.4.1 Exchange media and recording formats. The CADRG shall be normally exchanged on compact disk-read only memory (CD-ROM) media. In addition, CADRG may be distributed on the recordable compact disks (CD-R), 130 mm (5.25-inch) erasable optical disks (EOD), 8 mm magnetic tape, and 4 mm magnetic tape cartridges. The media standards, listed in TABLE 1, and recording format standards for these media are as specified in MIL-STD-2411. Unlike the source ADRG files, the contents of CADRG files do not conform to FIPS PUB 123 (ISO 8211) standards.

TABLE 1. CADRG Media Standards.

Interchange Media	Recording Standard	Volume/File Structure
CD-ROM	ISO/IEC DIS 10139	ISO 9660
CD-R (Recordable)	TBD	TBD
Erasable Optical Disk	ISO/IEC DIS 10089	ISO 13346 (Non-Sequential Recording)
8 mm Tape Cartridge	ISO/IEC DIS 11319	IEEE 1003.1 (paragraph 10.1.1) "Extended tar"
4 mm Tape Cartridge	ISO/IEC DIS 10777	IEEE 1003.1 (paragraph 10.1.1) "Extended tar"

2.4.2 Source digitized graphics. CADRG is derived from ADRG and other miscellaneous maps/charts or non-DMA maps. The CADRG scales and original source maps and their codes are listed in section 5.1.4 of MIL-STD-2411-1. These codes are used within the [frame file] designator names, as specified in APPENDIX 30.6.

3.4.3 Projection system. The ARC system, as described in MIL-A-89007, divides the surface of the earth ellipsoid into 18 latitudinal bands called zones. Zones 1-9 cover the Northern hemisphere and zones 10-18 (A through J, exclusive of I in CADRG) cover the Southern hemisphere. One zone in each hemisphere covers the polar areas. Each non-polar zone covers a part of the ellipsoid between two latitude limits and completely encircles the Earth. The nominal zone limits for CADRG are the same as for the source ADRG, as listed in TABLE 2. The extents of the CADRG zone overlaps are defined in APPENDIX 60.

TABLE 2. CADRG Zone Limits.

Zone Number	Equatorward Latitude	Midpoint Latitude	Poleward Latitude
1,A	0°	22.94791772°	32°
2,B	32°	41.12682127°	48°
3,C	48°	52.28859923°	56°
4,D	56°	60.32378942°	64°
5,E	64°	66.09421768°	68°
6,F	68°	70.10896259°	72°
7,G	72°	74.13230145°	76°
8,H	76°	78.17283750°	80°
9,J	80°	——	90°

3.4.4 Distribution frames. The CADRG database is composed of rectangular grids of frames of pixels for each zone. CADRG can be distributed in rectangular or non-rectangular areas, and with contiguous or non-contiguous coverage (i.e., areas separated by large expanses of water, or multiple discrete maps for which no contiguous maps exist). Each frame is represented by a discrete file. The CADRG library is seamless; that is, the edges of contiguous source maps are indistinguishable, except by color variations that are due to the differences between the colors or patterns in original source graphics. The raster graphic data from each (sub)frame abuts the data of neighboring (sub)frames exactly to provide unbroken coverage. Gaps in coverage exist where the source coverage does not exist. The boundaries of the distribution frames (see 3.5) are not required to coincide with the source map edges.

3.4.5 Data file organization. CADRG data files are arranged in a hierarchical directory/subdirectory structure (see FIGURE 1). The CADRG directories and data files, enumerated below, are fully described in paragraphs 3.11 through 3.12. All names and labels, and the format and structure of directories shall adhere to the conventions specified in MIL-STD-2411. Any computer system that can access distribution media conforming to the standards listed in TABLE 1 should be able to access CADRG data.

a. Root Directory: Contains [table of contents file], one or more directories of [frame file]s, a [legend directory], and one or more [overview image]s. The root directory shall be named "RPF".

```
[rpf root directory] (unordered)
    {1} (unordered)
    [table of contents file]
    [overview image] (1, ... many)
    [legend directory] (0, 1)
         {2}
         [legend file] (1, ... many)
    {1} (unordered)
    [frame directory] (0, ... many)
         {2}  (unordered)
         [frame file] (0, .. many)
         [subordinate directory] (0, ... many) (unordered)
              {3}
              [frame file] (0, ... many)
```

FIGURE 1a. <u>CADRG Directory and File Structure</u>.

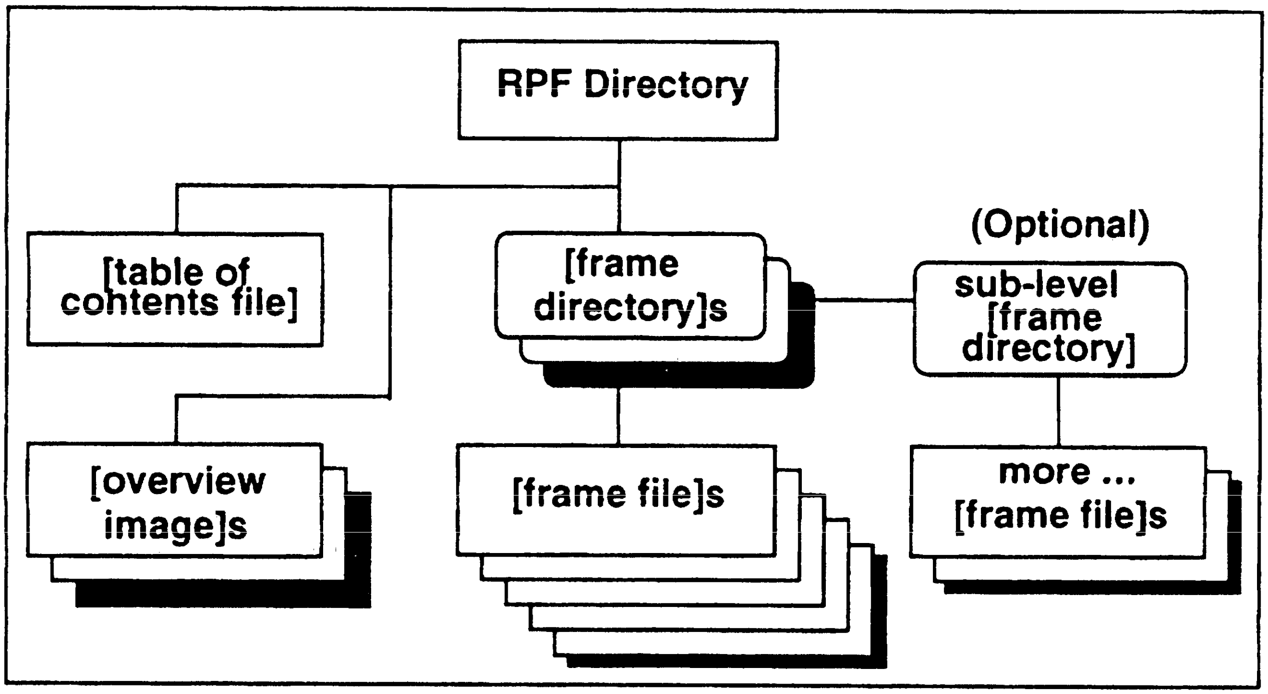

FIGURE 1b. Pictorial Representation of CADRG Directory and File Structure

b. [table of contents file]: The [table of contents file] provides an overview of the data contents of the distribution media. The [frame file index section] within the [table of contents file] provides path names to each of the [frame file]s on the interchange volume. The path names to the [frame file]s will be used by user applications software to locate the [frame file]s, rather than assume any particular names or directory structure.

c. [frame file directory]s: CADRG producers will choose the number of [frame file directory]s in a given volume and convention for assigning [frame file]s to directories. Each [frame file directory] on a given interchange volume shall be uniquely named in a manner to be determined by an authorized producer. The producers may also assign nested [frame file directory]s as needed to organize the [frame file]s, using a variable hierarchy.

d. [frame file]s: The [frame file]s contain the tiled image and support data for the geographic frames on a CADRG interchange volume. Each [frame file] (see 3.12) shall include a [header section], [location section], [coverage section], [compression section], [color/grayscale section], [image section], [attribute section] (optional), [related image section] (optional), and [replace/update section] (only present for replacements and updates). The [frame file] naming convention shall be in accordance with MIL-STD-2411, and is described in section 30.6 of the APPENDIX.

e. [legend file](s): The [legend file](s) contain(s) the tiled image data which represent the legend information from the original map series. Only one [legend file] is provided per map series; however, there are provisions for multiple [legend file]s per distribution volume. Each [legend file] (see 3.11.2) shall include a [header section], [location section], [compression section], [color/grayscale section], [image section], and [replace/update section] (only present for replacements and updates). [legend file]s shall be located within the [legend directory] which shall be named "RPF/LEGEND.".

f. [overview image](s): One or more [overview image]s will be provided per CADRG interchange media. These indicate graphically where the [frame file]s are located with respect to political and ocean boundaries, similar to the Location Diagram (see 5.1.2) on the jewel-box liner. [overview image]s will be located at the same level on the media as the [table of contents file]. Each [overview image] (see 3.11.3) shall include a [header section], [location section], [compression section], [color/grayscale section], and [image section].

3.4.6 Data formats. Data recording shall adhere to the conventions for logical data recording formats as specified in section 4.4 of MIL-STD-2411. CADRG files shall be integrated with the NITF message format in accordance with MIL-STD-2411-2.

3.5 Frame and subframe structure.

3.5.1 Pixel spacing. The original source graphics for ADRG data (from which CADRG are derived) are scanned at a 100 micron (μ) pixel resolution (254 pixels per inch) in both East-West and

North-South directions, and then warped from the datum of the original paper map or chart to the ARC projection using the WGS-84 ellipsoid. To produce CADRG, ADRG source data shall be spatially reduced (see 3.10.2) from the ADRG pixel spacing to a 150 μ pixel spacing (169 pixels per inch). For each map or chart scale, a constant latitudinal (row) and longitudinal (column) pixel interval shall exist in each zone, as defined in section 60 of the APPENDIX. The numbers of CADRG pixels in the longitudinal direction shall be adjusted so that there are integral numbers of subframes per zone. In the polar zone, the number of CADRG pixels is adjusted so that there is an even number of subframes across the zone in each dimension.

3.5.2 Frame and subframe tiling.

a. Each frame shall comprise a rectangular array of 1536 by 1536 pixels (2,359,296 pixels). Each frame shall be tiled into a grid of 6 by 6 subframes (36 subframes) Each subframe shall comprise a rectangular array of 256 by 256 output pixels (65,536 pixels). Subframes shall be numbered as depicted in FIGURE 2, in accordance with MIL-STD-2411.

b. All frames and subframes within a zone shall abut in a mutually exclusive manner without any pixel overlap or pixel redundancy. The northern and southern boundaries of a zone generally will not fall exactly on the northern and southern boundaries of a frame or subframe. There shall be frame overlap between the zones, as defined in section 3.5.4.

c. For several scales of source product, APPENDIX 60 lists the number of frame and subframe rows and columns in each zone for the latitudinal and longitudinal directions, East-West pixel spacing constants (i.e., the number of pixels for 360° longitude), North-South pixel spacing constants (i.e., number of pixels in 90° from equator to pole), longitudinal pixel sizes (meters) for each zone, and the latitudinal pixel sizes (meters).

d. The midpoint latitude for each zone shall be the same as for the ADRG source product (see 3.4.3).

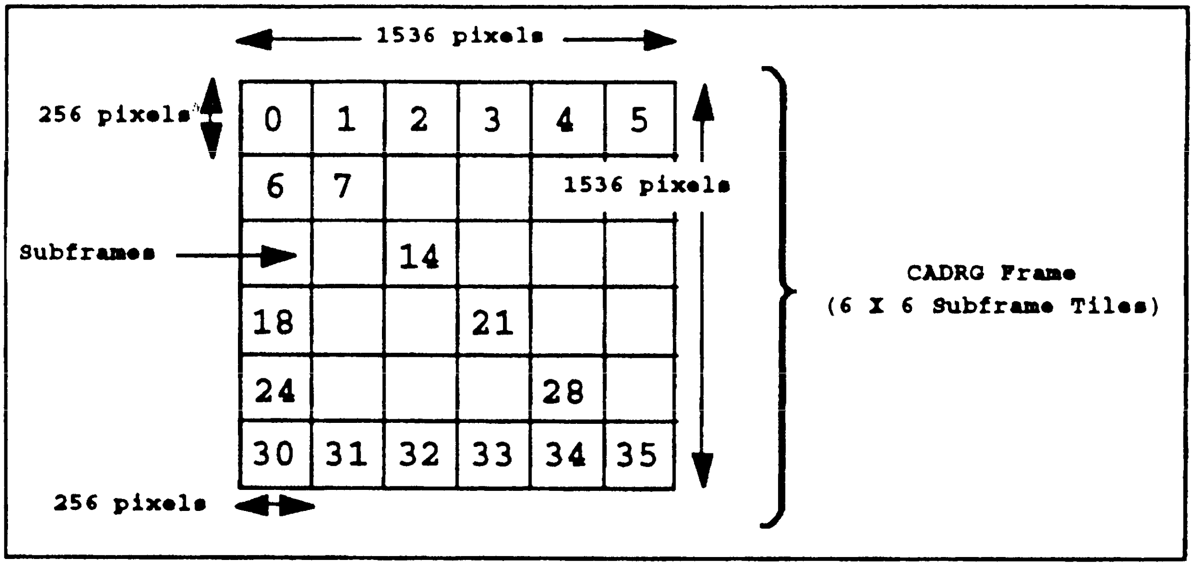

FIGURE 2. CADRG Frame/Subframe Structure.

3.5.3 Numbering and origin conventions.

a. The numbering convention for entities that are internal to the [frame file]s shall conform to MIL-STD-2411. All index numbers shall start from 0. Rows and columns of subframes in a frame, pixels, and indices in [frame file] subentities shall be counted from 0. The origin for the subframe and pixel numbering within frames and subframes shall be from the upper left corner. Subframes and pixels shall be counted in row-major order from the origin. Section 30 of the APPENDIX provides a set of coordinate conversions between pixel rows and columns within frames, and the latitude and longitude of a point within a frame based upon the coordinate information provided within the [coverage section] of each [frame file].

b. In addition, CADRG frames may be considered to form conceptual "rows" and "columns" within zones. Section 30.6 of the APPENDIX uses this concept to define the naming convention of frames for various scales by using the scale and zone specific "frame number." The rows and columns are numbered from 0. The origin for counting non-polar frame rows and columns in both the northern and southern hemispheres is the southernmost latitude of the zone, and 180° west longitude, with columns counted in an easterly direction from that origin. The origin for counting polar frames (see 3.5.5) is the lower-left corner of the polar zone, with rows and columns numbered from that origin. Section 30 of the APPENDIX provides the coordinate conversions for points within a frame file.

3.5.4 Non-polar frame overlap.

a. The longitudinal and latitudinal extents of the zones in the southern hemisphere are identical to those in the northern hemisphere.

b. Rows of frames from different zones do not have the same longitudinal extent since the longitudinal pixel intervals differ.

c. For each non-polar zone N, the top-most frame row of that zone corresponds in latitude with the bottom-most frame row of zone N+1 (as depicted in FIGURE 3). Thus the frames at the top and bottom rows of each zone shall overlap frames of those zones above and below. The zone overlap shall be a full frame.

3.5.5 Frame and subframe structure for polar regions. The CADRG frame and subframe structure is unique in the polar regions, in conjunction with the source products. CADRG shall use a polar stereographic projection, in which meridians (constant longitude) are plotted as radii emanating from the poles, and parallels (constant latitude) are plotted as concentric circles that are centered at the poles.

a. The north and south polar zones, 9 and J, are depicted in FIGURE 4 and FIGURE 5, respectively. These zones are circular with the pole at the center and the radius being the distance from the pole to 80° (north or south) latitude. The polar frame structure is square. The center frame is positioned with the pole in the exact center of that frame and the sides of the frame making right angles with the 0°, 90°E, 180°W, and 90°W meridians. The origin for polar zone frame rows and columns (see 3.5.3.b) is the lower-left corner of the zone. Polar CADRG frames are not all oriented along the north-south and east-west directions. Further detail on the frame structure and orientation is provided in section 60 of the APPENDIX.

b. The pixel coordinate system for polar zones is centered at the pole. Polar zone pixels are transformed from (<X>, <Y>) pixel row and column coordinates to latitude and longitude (ϕ, λ) coordinates, as described in section 30 of the APPENDIX. Pixel resolutions and sizes are not constant in a left-right or up-down direction. The number of pixels in the polar zone is adjusted so that there are an even number of subframes centered about the poles. There are an odd number of frames with symmetry about the pole. APPENDIX 60 provides calculations to compute average frame pixel resolution.

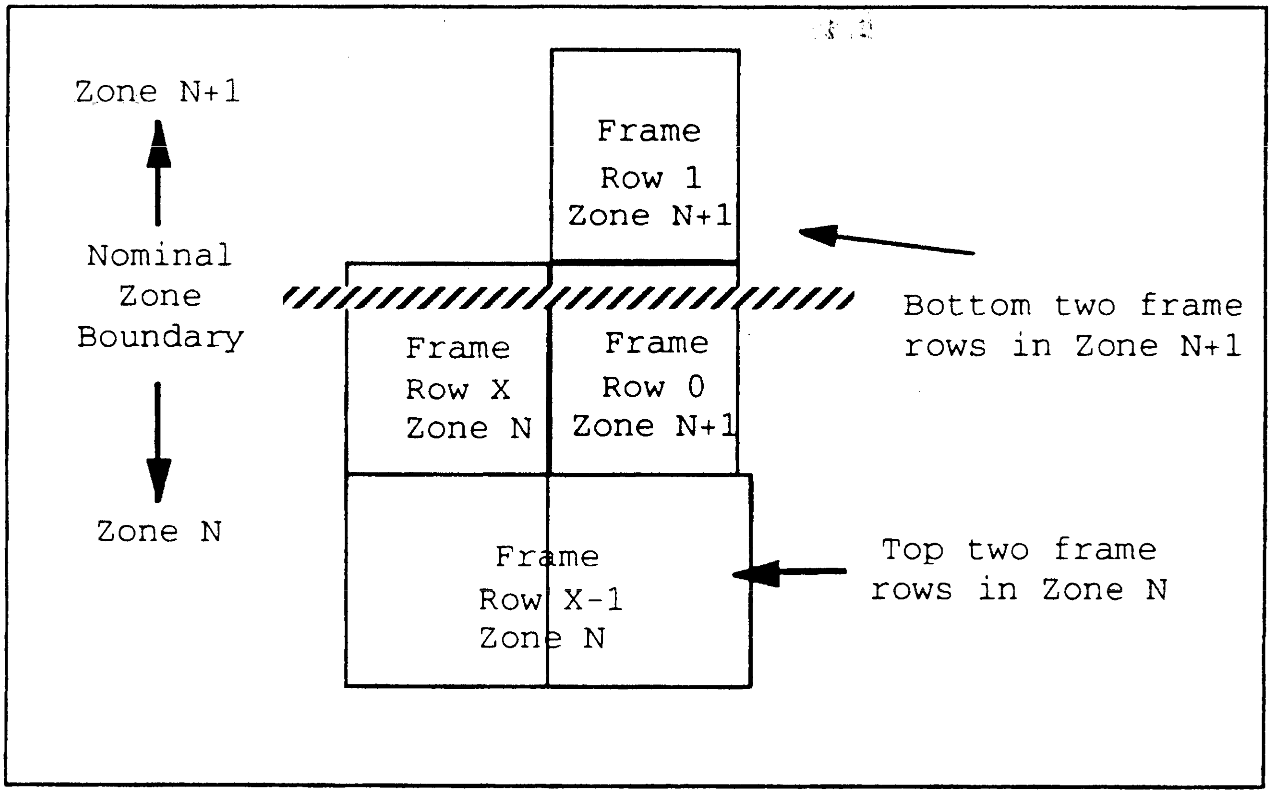

FIGURE 3. CADRG Zone Boundary Overlap Structure

3.5.6 Polar zone overlap. Polar zone overlap is limited by the source data. Polar frames are defined in polar stereographic projection and non-polar frames are in the ARC projection. ADRG often does not provide any overlap (below 80 degrees) in the polar zones, and overlap in zones 8 and H are limited to 1024 ADRG pixels (683 CADRG pixels). Thus, all "overlap" between zones 8 and H and the associated polar zones will be contained in zone 8 and H. Polar data will not be transformed to the ARC projection to provide a full 1536 pixels of overlap.

3.6 Coordinate reference systems.

3.6.1 Non-polar coordinates. Coordinates for row and column pixels in the non-polar zones are proportional to WGS-84 latitude and longitude of map features under the Equirectangular projection (as defined in *Map Projections—A Working Manual*, page 90). The coordinate conversions for the non-polar case are in 30.2 and 30.3 of the APPENDIX.

3.6.2 Polar coordinates. Pixel coordinates in the polar zones are proportional to rectangular coordinates of the Azimuthal Equidistant projection, polar aspect, spherical form (as defined in *Map Projections—A Working Manual*, page 191). The coordinate conversions for the polar case are provided in 30.4 and 30.5 of the APPENDIX.

3.6.3 WGS-84 coordinates. The WGS-84 coordinates for longitude and latitude in CADRG are signed values in the range $-180° \leq$ longitude $\leq +180°$ and $-90° \leq$ latitude $\leq +90°$.

3.7 Projection distortion.

3.7.1 Non-polar distortion. For the non-polar zones, some visual distortion is present due to a stretch (at the poleward latitude) and shrink (at equatorward latitude) in the East-West direction. There is no distortion (i.e., the nominal pixel interval is true) along a selected parallel at the mid-latitude (see TABLE 2) of each zone. The maximum stretch or shrink at the zone boundaries is the same as for ADRG. Since an entire [frame file] of overlap is included between zones, there can be noticeable visual distortion in the overlap area for the very small scale maps (e.g. GNC, JNC).

3.7.2 Polar distortion. Distortion in the polar zones is less than 10% for most scales.

3.8 Image formats. Each CADRG interchange volume contains compressed, transformed images from multiple source maps. The contents of approximately 75 to 500 source map sheets are contained on a single CADRG CD-ROM; this number varies with map series. These are recorded in [frame file]s (see 3.12). The [frame file]s include a [color/grayscale table] (see 3.12.6). The production goal should be to use a single [color/grayscale table] with all [frame file]s of the same scale in a common geographic area. An image decompression codebook exists for each CADRG frame. Each codebook is defined in the [compression section] of the [frame file] (see 3.12.5). Each compressed partial subframe shall be padded with "transparent" pixel kernels (see 3.15) to form a fully populated 256 x 256 matrix of pixels.

3.9 Source support data. Each CADRG interchange volume contains the following source support data:

a. Header data within the [table of contents file] and [frame file]s (see 3.11.1 and 3.12.1) that contains the critical configuration control information needed by software applications.

b. The [table of contents file] (see 3.11.1) that describes the bounds and locations of actual data, and pathnames to the [frame file]s and their locations.

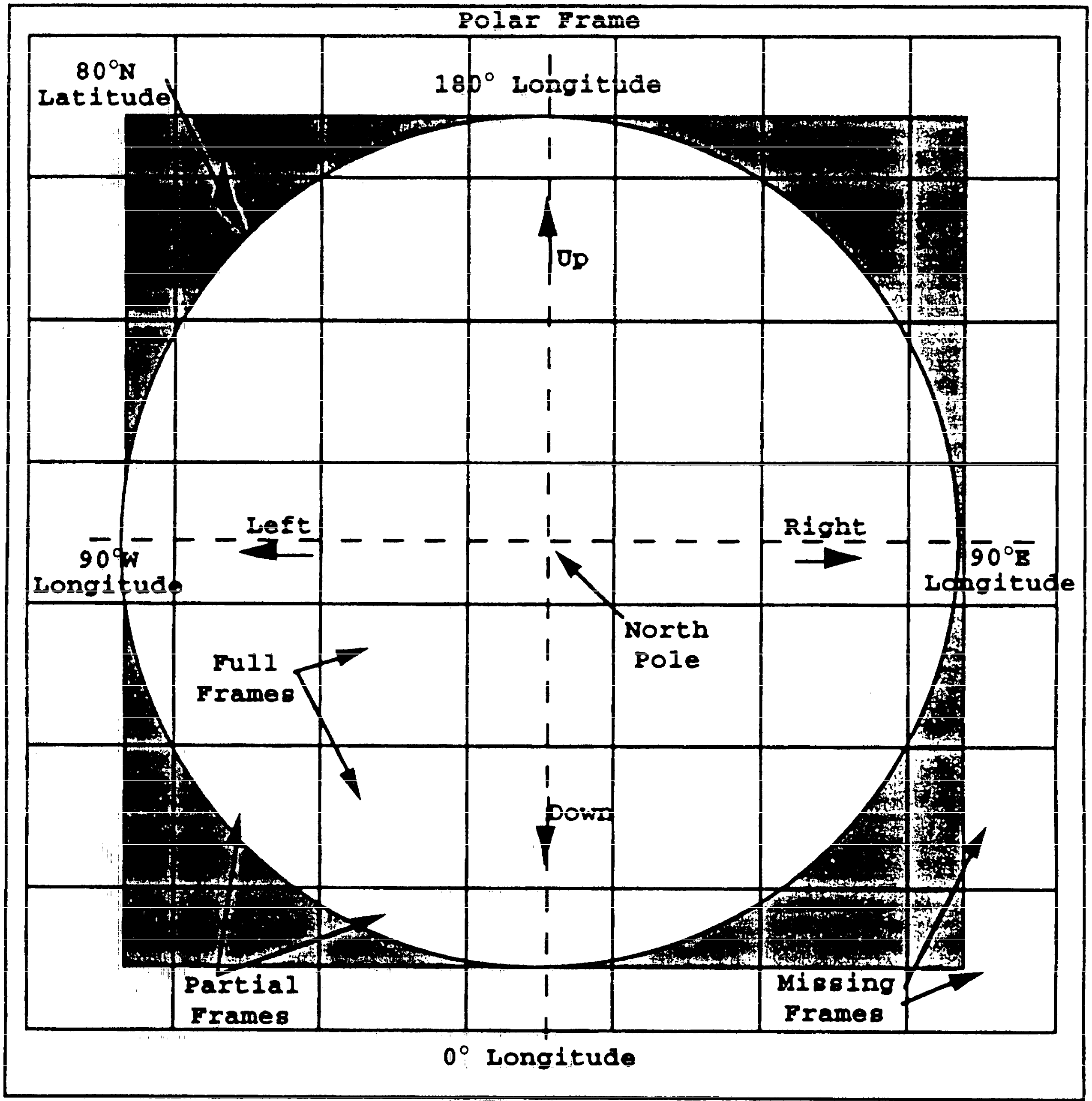

FIGURE 4. Frame Orientation for the North Polar Zone.

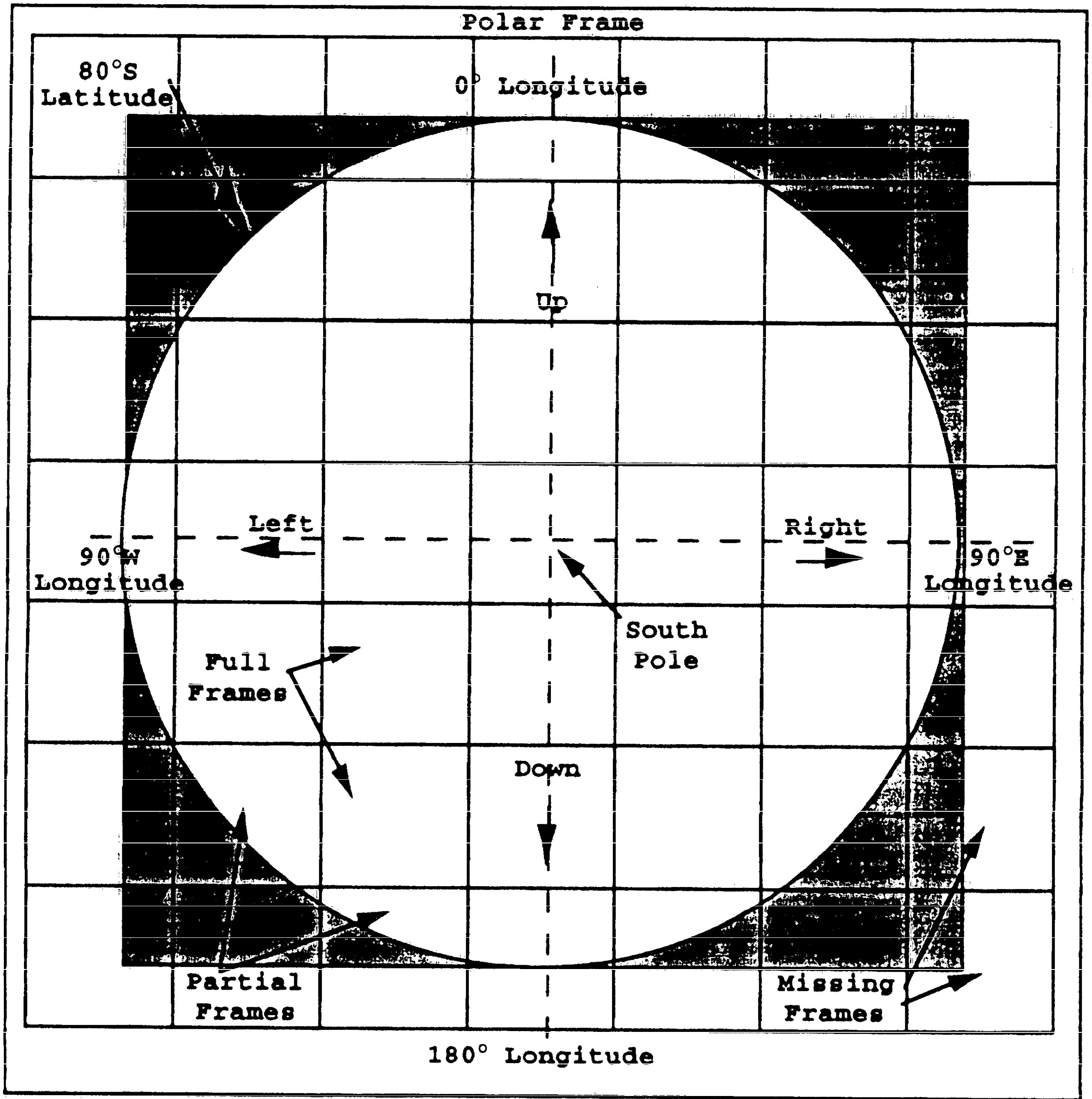

FIGURE 5. Frame Orientation for the South Polar Zone.

c. Configuration management data in the [replace/update section] (see 3.12.4) which provides the replace/update history of successive versions or updates to the CADRG image data within each frame. This section is always present with the exception of the first edition of a [frame file].

d. Attribute data in the [attribute section] (see 3.12.8) that gives important information about the source graphic. Much of this information is derived from the marginalia of the source graphic, and includes accuracy, original projection, datums, etc.

e. Graphic support data in the [legend file]s and [overview image]s (see 3.11.2 and 3.11.3). The [legend file]s provide a graphic representation of the legend information for each map series. The [overview image]s provide a depiction of the extent and locations of the [frame file]s on the interchange media.

3.10 Preparation of source material.

3.10.1 Source data. The source data for CADRG production are ADRG data produced by DMA or other maps and charts listed in MIL-STD-2411-1. Any map information that is included in these data sources at the time of CADRG production may be included for distribution. CADRG updates will be incorporated concurrently with updates to the source data. It will be possible to directly update CADRG digital image data with digital map updates.

3.10.2 Spatial reduction. The algorithm for performing the spatial reduction shall create the pixel intervals as defined in section 60 of the APPENDIX. The interpolation and subsampling of the ADRG data shall employ smoothing and edge sharpening filtering to remove downsampling artifacts. One method for spatial reduction and filtering is described in the Southard (1992) and Markuson (1993) references.

3.10.3 Color reduction. During compression, the available colors in the ADRG source data shall be quantized from a palette of 16.7 million possible colors to a maximum 216 colors in the CADRG [frame file]s. (This allows 8-bit systems to have 40 colors reserved for other uses by applications software.) Products 1:500,000 scale and smaller will have zone-wide color tables. Products 1:250,000 and larger may have either zone-wide color tables or multiple color tables in a zone. The quantized colors shall be defined in a lookup table (LUT) with 216 entries. (A 217th entry is reserved for transparent (see 3.16) pixels.) Additional color tables are provided wherein each of the 216 colors in the primary color table is mapped to a color in the reduced color table through use of a color conversion table, as defined in MIL-STD-2411. Standard CADRG data sets will include 216, 32, and 16 entry color tables.

3.10.4 Compression algorithm. Spatial compression shall be performed using a Vector Quantization (VQ) algorithm that employs a 4 x 4 compression kernel size with 4096 codebook entries. One method for the VQ process is described in the Southard (1992) and Markuson (1993) references.

3.11 CADRG volume support data. Each CADRG volume shall contain support information for the [frame file]s contained therein. This information shall consist of: a [table of contents file], [legend file]s, and [overview image](s).

3.11.1 The [table of contents file]. The structure and data types for the [table of contents file] are completely defined in MIL-STD-2411 and MIL-STD-2411-1.

3.11.2 The [legend file]. CADRG [frame file]s contain (in the headers and attributes) virtually all of the ancillary support information of the original paper maps. The legend of source maps, however, are not easily provided in a non-graphical form. Therefore, each CADRG volume may contain a [legend file] for each map series that is included on the volume. The structure of the [legend file] shall be similar to that of the CADRG [frame file] (it is, in fact, an RPF [frame file]) The [legend file] shall be composed of 256 x 256 pixel subframes, and it shall be compressed in the same manner as CADRG [frame file]s, however, the image may contain as many rows and columns of subframes (e.g. 3 x 3, 6 x 8) as are necessary to encapsulate the entire legend. The RPF [coverage section], [related image section], and [attribute section]s are not included because they are not relevant to the [legend file]. The processing of the [legend file] may or may not include spatial downsampling; the primary objective will be legibility of the legend information. In all other respects, the [legend file] shall be identical to the CADRG [frame file]. It is a fully compliant RPF [frame file] and properly written software should be able to exploit it using the same code as is used for CADRG [frame file]s. The naming convention for [legend file]s shall be *NNNNNNNN*.LGD, where *NNNNNNNN* represents a unique file name, assigned by the producer. The file name(s) for the appropriate [legend file](s) will be included in the [related image section] of each CADRG [frame file], along with a [legend file] relationship code. If more than one [legend file] is related to a CADRG [frame file], then the legend file name attribute can be used to identify the appropriate [legend file] for the applicable area.

3.11.3 The [overview image]. The [overview image] is a graphic which portrays the coverage of the contents of the CADRG volume. The structure of the [overview image] is identical to that of the CADRG [frame file], except that it does not include a [coverage section], [attribute section], [related image section], or [replace/update section]. The naming convention for the [overview image] shall be *NNNNNNNN*.OVR, where *NNNNNNNN* represents a file name that allows the user to distinguish among multiple [overview image]s on the volume. [overview image] file names are not required to be unique; [overview image]s on different volumes may have the same file name.

3.12 The [frame file]. The data for each CADRG frame is provided in separate [frame file]s. Each [frame file] comprises the logical sections described below, per MIL-STD-2411. Starting addresses for section components are designated with location pointers from the start of the [frame file]. When formatted within a NITF message, CADRG sections and components are physically distributed within portions of the NITF message, as described in MIL-STD-2411-2.

[header section]	
<little/big endian indicator>,bool:1	(00)H (big endian)
<header section length>, uint:2	48
<file name>,asci:12	0000Y016.GN1
<new/replacement/update indicator>,uint:1	(new)
<governing specification number>,asci:15	MIL-C-89038
<governing specification date>,asci:8	19940901
<security classification>,asci:1	U
<security country/international code>,asci:2	us
<security release marking>,asci:2	uu
<location section location>,uint:4	48

FIGURE 6. Example CADRG [frame file] [header section].

3.12.1 The [header section]. The [header section] contains critical configuration control information. The structure and data types for a [header section] are defined in MIL-STD-2411. An example RPF [header section] is shown in FIGURE 6.

a. The <little/big endian indicator> for CADRG shall be (00)H, denoting big endian encoding for all distribution media.

b. The encoded <governing specification number> and <governing specification date> shall refer to editions of this CADRG specification, i.e., MIL-C-89038.

c. Other fields are identified by the producer as defined in MIL-STD-2411, or by registered values listed in MIL-STD-2411-1.

3.12.2 The [location section]. The [location section] designates the beginning byte addresses relative to the beginning of the [frame file] for the components in an RPF file. Its structure and data types shall be as defined in MIL-STD-2411. The <component id>s are defined within the MIL-STD-2411-1. Producers and software developers should use the address locations within the [location section], and not "hard-code" them. An example [location section] is shown in FIGURE 7.

```
[location section]

<location section length>,uint:2                                144
<component location table offset>,unit:4                         14
<number of component location records>,uint:2                    13
<component location record length>,uint:2                        10
<component aggregate length>,uint:4                          107404

[component location table]

<component id>,uint:2                                           130
<component length>,uint:4                                        96
<component location>,uint:4
         •         •         •         •         •
         •         •         •         •         •
<component id>,uint:2                                           143
<component length>,uint:4                                       254
<component location>,unit:4
```

FIGURE 7. Example CADRG [frame file] [location section].

3.12.3 The [coverage section]. The [coverage section] defines the geographic extent of the frame. The structure and data types for the [coverage section] in the CADRG product shall be as defined in MIL-STD-2411. This section includes four sets of latitude and longitude vertices that shall define the geographical extent of the [frame file]. Section 60.1 of the APPENDIX defines the four parameters that define the pixel resolutions and their intervals. A sample [coverage section] is shown in FIGURE 8.

```
[coverage section]

<northwest/upper left latitude>,real:8                    10.384615
<northwest/upper left longitude>,real:8                  178.134715
<southwest/lower left latitude>,real:8                     0.000000
<southwest/lower left longitude>,real:8                  178.134715
<northeast/upper right latitude>,real:8                   10.384615
<northeast/upper right longitude>,real:8                -170.673570
<southeast/lower right latitude>,real:8                    0.000000
<southeast/lower right longitude>,real:8                -170.673570
<north-south/vertical resolution>,real:8                 754.049988
<east-west/horizontal resolution>,real:8                 750.539978
<latitude/vertical interval>,real:8                        0.006761
<longitude/horizontal interval>,real:8                     0.007286
```

FIGURE 8. Example CADRG [frame file] [coverage section].

3.12.4 The [compression section]. The [compression section] shall provide tables of pixel vector codebook values necessary to decode the compressed image for the vector quantization algorithm used for CADRG; they will be used by the application software to decompress the image data. The method for reconstructing images from vector codebook tables, and image colors from color lookup tables, is outlined in section 3.14 below. No other parameters are required, so there is no [compression parameter subsection] in CADRG. The structure and data types for the [compression section] shall be as defined in MIL-STD-2411. An example [compression section] structure is depicted in FIGURE 9. The last /compression lookup value/ (i.e., index 4095) is used for the transparent kernel (see 3.15) in [frame file]s that have transparent pixels.

3.12.5 The [color/grayscale section]. The [color/grayscale table] contains the 216 Red-Green-Blue and Monochrome values that are pointed to by the color table indices in the [compression section]. Reduced-entry [color/grayscale tables] within the frame file provide color/grayscale tables with less than 216 entries. The CADRG product uses zone-wide color tables for some map scales; however, since the 8 bit lookup table is small, it is included within each [frame file]. The [color/grayscale section] provides quantized color table and associated grayscale values used for softcopy and hardcopy display of the image data in the [frame file]. The structure and data types for the [frame file] [color/grayscale section] in the CADRG product shall be as defined in MIL-STD-2411. An example [color/grayscale section] for CADRG is shown in FIGURE 10.

a. The <number of color/grayscale offset records> shall be at least one; thus, there is at least one [color/grayscale table] and one [histogram table] in a [frame file]. However, additional [color/grayscale table]s and [histogram table]s may be included to provide alternative color tables for any application that requires it. The user application software will select the color table that it will utilize. The mapping between the primary color table and the alternative color table will be provided in a color conversion table, as defined in MIL-STD-2411 and MIL-STD-2411-1. The conversion table will be identified by its <color converter table id>. For CADRG, the primary color table has 216 colors and its <color/grayscale id> ::= 2. A 217th entry is used in situations where [frame file]s contain transparent pixels, and is defined as the default transparent pixel color entry.

b. A [histogram subsection] shall be provided in each [frame file] with a [histogram table] containing 216 (indices 0 to 215) [histogram record]s, to define the absolute number of occurrences of the indexed color or grayscale value in the output pixel file for the [frame file]. The number of occurrences of transparent pixels are not included in the histogram tables.

3.12.6 The [image section]. The [image section] contains pointers to VQ compression kernels in the [compression section], that, in turn, point to color indices in the primary color table within the [color/grayscale table section]. The structure and data types for the [image section] in CADRG shall be as defined in MIL-STD-2411. An example [image section] structure is shown in FIGURE 11. The [subframe mask table] and [transparency mask table] are described in MIL-STD-2411. Null values of (FFFF FFFF)H in these tables indicate the subframes that contain no data, and subframes that do not have transparent pixels. Transparent kernels (see 3.15) may be used on the edges of the image.

```
[compression section]
[compression section subheader]
<compression algorithm id>,uint:2                                     1
<number of compression lookup offset records>,uint:2                  4
<number of compression parameter offset records>,uint:2               0

[compression lookup subsection]
<compression lookup offset table offset>,uint:4                       6
<compression lookup table offset record length>,uint:2               14

[compression lookup table offset record] (4 occurrences)
<compression lookup table id>,uint:2                                  1
<number of compression lookup records>,uint:4                      4096
<number of values per compression lookup record>,unit:2               4
<compression lookup value bit length>,unit:2                          8
<compression lookup table offset>,uint:4                             62

<compression lookup table id>,uint:2                                  2
<number of compression lookup records>,uint:4                      4096
<number of values per compression lookup record>,unit:2               4
<compression lookup value bit length>,unit:2                          8
<compression lookup table offset>,uint:4                          16446

<compression lookup table id>,uint:2                                  3
<number of compression lookup records>,uint:4                      4096
<number of values per compression lookup record>,unit:2               4
<compression lookup value bit length>,unit:2                          8
<compression lookup table offset>,uint:4                          32830

<compression lookup table id>,uint:2                                  4
<number of compression lookup records>,uint:4                      4096
<number of values per compression lookup record>,unit:2               4
<compression lookup value bit length>,unit:2                          8
<compression lookup table offset (uint:4                          49214

[compression lookup table] (4)
Compression Table 0:  4096 4 byte indices:                   16K Bytes
<compression lookup value> (0) =   0   0   0   6
<compression lookup value> (1) =   0  14   0   1
<compression lookup value> (2) =   0   0  16   0
<compression lookup value> (3) =   0   4   0   8
   .      .      .      .      .
   .      .      .      .      .
Compression Table 1:  4096 4 byte indices:                   16K Bytes
<compression lookup value> (0) =  12  88  50  12
<compression lookup value> (1) =  59  50  50  12
<compression lookup value> (2) = 142 174  44  44
   .      .      .      .      .
   .      .      .      .      .
Compression Table 2:  4096 4 byte indices:                   16K Bytes
Compression Table 3:  4096 4 byte indices:                   16K Bytes
```

FIGURE 9. Example CADRG [frame file] [compression section].

```
[color/grayscale section]
[color/grayscale section subheader]

<number of color/grayscale offset records>,uint:1                3
<number of color converter offset records>,uint:1                2
<external color/grayscale file name>,asci:12             <sp> filled

[colormap subsection]
<colormap offset table offset>,uint:4                            6
<color/grayscale offset record length>,uint:2                   17

[colormap offset table]
[color/grayscale offset record]
<color/grayscale table id>,uint:2                                2
<number of color/grayscale records>,uint:4                     216
<color/grayscale element length>,uint:1                          4
<histogram record length>,uint:2                                 4
<color/grayscale table offset>,uint:4                           57
<histogram table offset>,uint:4                               1113

[color/grayscale offset record]
<color/grayscale table id>,uint:2                                2
<number of color/grayscale records>,uint:4                      32
<color/grayscale element length>,uint:1                          4
<histogram record length>,uint:2                                 4
<color/grayscale table offset>,uint:4                          921
<histogram table offset>,uint:4                               1977

[color/grayscale offset record]
<color/grayscale table id>,uint:2                                2
<number of color/grayscale records>,uint:4                      16
<color/grayscale element length>,uint:1                          4
<histogram record length>,uint:2                                 4
<color/grayscale table offset>,uint:4                         1049
<histogram table offset>,uint:4                               2105

[color/grayscale element group]
[color/grayscale table] (≥ 1)
[color/grayscale record] (216)
Color Table 0:  216 4-byte records:                      864 Bytes
<color/grayscale element (0)    =   3  17 168  29
<color/grayscale element (1)    = 247 243 243 244
<color/grayscale element (2)    =   0   0   0   0
<color/grayscale element (3)    = 242 228 224 231
•        •        •        •        •
•        •        •        •        •
<color/grayscale element (214)  =  57  64 126  68
<color/grayscale element (215)  =  99  47  70  65
```

FIGURE 10. Example CADRG [frame file] [color/grayscale section].

```
Color Table 1:  32 4-byte records:                          128 Bytes
<color/grayscale element (0)   =  23  38 170  48
<color/grayscale element (1)   = 229 224 110 212
<color/grayscale element (2)   = 236 231 227 232
<color/grayscale element (3)   =   2   0   2   0
•        •       •        •       •
•        •       •        •       •
<color/grayscale element (30)  =  60  43  96  54
<color/grayscale element (31)  =  24   9  35  16

Color Table 2:  16 4-byte records:                           64 Bytes
<color/grayscale element (0)   =  29  43 162  52
<color/grayscale element (1)   = 221 214 113 204
<color/grayscale element (2)   = 213 210 195 209
<color/grayscale element (3)   =   2   1   2   1
•        •       •        •       •
•        •       •        •       •
<color/grayscale element (14)  =  80  15  12  34
<color/grayscale element (15)  =  63  74 156  80

[histogram element group]
[histogram table] (3)
[histogram record] (216)
Histogram Table 0:  216 4-byte records:                     864 Bytes
<histogram element> (0) =    0
<histogram element> (1) = 7450
<histogram element> (2) =  898
<histogram element> (3) =   14
•        •       •        •
•        •       •        •
<histogram element> (214) = 60
<histogram element> (215) =  0

Histogram Table 1:  32 4-byte records:                      128 Bytes
<histogram element> (0) =    0
<histogram element> (1) =    6
<histogram element> (2) = 7475
<histogram element> (3) = 1098
•        •       •        •
•        •       •        •
<histogram element> (30) = 111
<histogram element> (31) = 219
```

FIGURE 10. Example CADRG [frame file] [color/grayscale section] (continued).

```
Histogram Table 2:  16 4-byte records:                      64 Bytes
<histogram element> (0) =    5
<histogram element> (1) =   44
<histogram element> (2) = 7605
<histogram element> (3) = 1794
•          •        •          •
•          •        •          •
<histogram element> (14) =   0
<histogram element> (15) = 286

[color converter subsection]

<color converter offset table offset>,uint:4                       8
<color converter offset record length>,uint:2                     18
<color converter record length>,uint:2                             4

[color converter offset table]
[color converter offset record]
<color converter table id>,uint:2                                  5
<number of color converter records>,uint:4                       216
<color converter table offset>,uint:4                             44
<source color/grayscale table offset>,uint:4                       6
<target color/grayscale table offset>,uint:4                      23

[color converter offset record]
<color converter table id>,uint:2                                  5
<number of color converter records>,uint:4                       216
<color converter table offset>,uint:4                            908
<source color/grayscale table offset>,uint:4                       6
<target color/grayscale table offset>,uint:4                      40

Color Converter Table 0:  216 4-byte records:              864 Bytes
<target color/grayscale table entry number> (0)    =  0
<target color/grayscale table entry number> (1)    =  2
<target color/grayscale table entry number> (2)    =  3
<target color/grayscale table entry number> (3)    =  2
•          •        •          •
•          •        •          •
<target color/grayscale table entry number> (214)  = 13
<target color/grayscale table entry number> (215)  = 22

Color Converter Table 1:  216 4-byte records:              864 Bytes
<target color/grayscale table entry number> (0)    =  0
<target color/grayscale table entry number> (1)    =  2
<target color/grayscale table entry number> (2)    =  3
<target color/grayscale table entry number> (3)    =  2
•          •        •          •
•          •        •          •
<target color/grayscale table entry number> (214)  = 15
<target color/grayscale table entry number> (215)  =  9
```

FIGURE 10. Example CADRG [frame file] [color/grayscale section] (concluded).

```
[image section]
[mask subsection]

<subframe sequence record length>, uint:2                              4
<transparency sequence record length>, uint:2                          0
<transparent output pixel code length>,uint:2                          8
/transparent output pixel code/,bits:8                               255

[subframe mask table] (0,1)

<subframe offset> for subframe 0,0 (uint:4)                            0
<subframe offset> for subframe 0,1 (uint:4)                         null
<subframe offset> for subframe 0,2 (uint:4)                         null
<subframe offset> for subframe 0,3 (uint:4)                         null
<subframe offset> for subframe 0,4 (uint:4)                         null
<subframe offset> for subframe 0,5 (uint:4)                         null
<subframe offset> for subframe 1,0 (uint:4)                         6144
<subframe offset> for subframe 1,1 (uint:4)                         null
<subframe offset> for subframe 1,2 (uint:4)                         null
<subframe offset> for subframe 1,3 (uint:4)                         null
<subframe offset> for subframe 1,4 (uint:4)                         null
<subframe offset> for subframe 1,5 (uint:4)                         null
<subframe offset> for subframe 2,0 (uint:4)                        12288
<subframe offset> for subframe 2,1 (uint:4)                         null
    •           •       •        •         •
    •           •       •        •         •
<subframe offset> for subframe 5,0 (uint:4)                        30720
<subframe offset> for subframe 5,1 (uint:4)                         null
<subframe offset> for subframe 5,2 (uint:4)                         null
<subframe offset> for subframe 5,3 (uint:4)                         null
<subframe offset> for subframe 5,4 (uint:4)                         null
<subframe offset> for subframe 5,5 (uint:4)                         null
```

FIGURE 11. Example CADRG [frame file] [image section].

```
[image description subheader]
<number of spectral groups>,uint:2                                      1
<number of subframe tables>,uint:2                                      6
<number of spectral band tables>,uint:2                                 1
<number of spectral band lines per image row>,uint:2                    1
<number of subframes in east-west or left-right
  direction>,uint:2                                                     6
<number of subframes in north-south or up-down
  direction>,uint:2                                                     6
<number of output columns per subframe>,uint:4                        256
<number of output rows per subframe>,uint:4                           256
<subframe mask table offset>,uint:4                                     7
<transparency mask table offset>,uint:4                              null

[image display parameters subheader]
<number of image rows>,uint:4                                          64
<number of image codes per row>,uint:4                                 64
<image code bit length>,uint:1                                         12

[spatial data subsection]
[spectral group] (1)
[subframe table] (1, ... 36)
[spectral band table] (1)
[image row] (64)
[spectral band line] (1)
/image code/,bits:12 (64)                                  {Sample Below}

Codebook:                    | 1024 | 2048  |  3072 | 4095 |
12-bit Values:               |  400 |  800  |   C00 |  FFF |
Bytes:                       | 40 | 08 | 00 | C0 | 0F | FF |

/image code/s:
  58   1690   1252   0786   1814   1808   0643   2913
 667   3267   3917   3794   1644   1059     36   2725
1466   3532   1338   1203   3860   1739    220   1310
  .       .      .      .      .
  .       .      .      .      .
```

FIGURE 11. Example CADRG [frame file] [image section] (concluded).

3.12.7 The [attribute section]. The [attribute section] will define ancillary or qualifying data about the overall frame image or areal subsets of the image. The structure and data types for the [attribute section] shall be as defined in MIL-STD-2411. An example [attribute section] structure is shown in FIGURE 12.

a. Pointers to attributes and one or more parameters for those attributes are enumerated for each areal extent in the [offset record]s. The <parameter offset>s in these records point to the actual values or codes for the parameters in the [attribute record]s.

b. The attribute descriptions and their identifiers, and parameter descriptions and identifiers for CADRG are listed in APPENDIX 50. The actual values/codes used for <parameter value>s in [attribute record]s shall be as defined in MIL-STD-2411-1.

c. If the areal extent of the values for a given attribute is an entire frame, then the <areal coverage sequence number>s shall be set to zero. Otherwise, they shall point to an [explicit areal coverage record] which contains three or more latitude/longitude vertices of the areal extent for the attribute parameters; the areal extent may be irregularly shaped.

3.12.8 The [replace/update section]. The [replace/update section] will provide the genealogy of the [frame file] through successive replacements (editions) and updates. It is included for all replacement and update [frame file]s. The structure and data types for the [replace/update section] in the CADRG product shall be as defined in section 5.1.6 of MIL-STD-2411.

3.13 Storage requirements. Including overhead, the CADRG image data is approximately 55:1 compressed with respect to the source ADRG image data. The storage requirements for these items are discussed in APPENDIX 40. For CADRG, as much as 650 Mbytes can be stored on a CD-ROM. Storage on other distribution media will be appropriate to the data capacity of that media.

```
[attribute section] (0, 1)
[attribute section subheader]
<number of attribute offset records>,uint:2                            36
<number of explicit areal coverage records>,uint:2                      3
<attribute offset table offset>,uint:4                                  0
<attribute offset record length>,uint;2                                 8

[attribute subsection]
[attribute offset table]
[attribute offset record]
<attribute id>,uint:2                                                   1
<parameter id>,uint:1                                                   1
<areal coverage sequence number>,uint:1                                 0
<attribute record offset>,uint:4                                      288

[attribute offset record]
<attribute id>,uint:2                                                   2
<parameter id>,uint:1                                                   1
<areal coverage sequence number>,uint:1                                 0
<attribute record offset>,uint:4                                      296

[attribute offset record]
<attribute id>,uint:2                                                   7
<parameter id>,uint:1                                                   1
<areal coverage sequence number>,uint:1                                 0
<attribute record offset>,uint:4                                      304

[attribute offset record]
<attribute id>,uint:2                                                   3
<parameter id>,uint:1                                                   1
<areal coverage sequence number>,uint:1                                 3
<attribute record offset>,uint:4                                      308
   .        .        .        .        .
   .        .        .        .        .

[attribute table]
[attribute record]
<parameter values>: Currency Date (asci:8)                       19940122
<parameter values>: Production Date (asci:8)                     19940122
<parameter values>: Horizontal Datum (asci:4)                         WGE
<parameter values>: Significant Date (asci:8)                    19830914
   .        .        .        .        .
   .        .        .        .        .

[explicit areal coverage subsection]
<explicit areal coverage table offset>,uint:4                           8
<explicit areal coverage record length>,uint:2                         82
<corner coordinates record length>,uint:2                              16
```

FIGURE 12. Example CADRG [frame file] [attribute section]

```
[explicit areal coverage table]
[explicit areal coverage record]
<number of vertices>,uint:2 =    5
[corner coordinates record]
<lat>,real:8                =    0.000000
<long>,real:8               =  143.500000
<lat>,real:8                =   40.000000
<long>,real:8               =  143.500000
<lat>,real:8                =   40.000000
<long>,real:8               = -156.000000
<lat>,real:8                =    0.000000
<long>,real:8               = -156.000000
<lat>,real:8                =    0.000000
<long>,real:8               =  143.500000

[explicit areal coverage record]
<number of vertices>,uint:2 =    5
[corner coordinates record]
<lat>,real:8                =    0.000000
<long>,real:8               =  143.500000
<lat>,real:8                =   40.000000
<long>,real:8               =  143.500000
<lat>,real:8                =   40.000000
<long>,real:8               = -156.000000
<lat>,real:8                =    0.000000
<long>,real:8               = -156.000000
<lat>,real:8                =    0.000000
<long>,real:8               =  143.500000

[explicit areal coverage record]
<number of vertices>,uint:2 =    5
[corner coordinates record]
<lat>,real:8                =   40.000000
<long>,real:8               =  143.500000
<lat>,real:8                =   40.000000
<long>,real:8               =  145.000000
<lat>,real:8                =    0.000000
<long>,real:8               =  145.000000
<lat>,real:8                =    0.000000
<long>,real:8               =  143.500000
<lat>,real:8                =   40.000000
<long>,real:8               =  143.500000
```

FIGURE 12. Example CADRG [frame file] [attribute section] (concluded).

3.14 CADRG decompression. All information required for decompression of a CADRG [frame file] is contained within the file itself. Software for the decompression of CADRG data should be written so that offset values and file structures can change without needing to modify the application software. This section describes the specific parameters required for the decompression of CADRG data. Other compressed products conforming to the RPF standard will require different parameters and processing for decompression. These values will be described in the specifications for each product.

3.14.1 Overview. CADRG decompression involves replacing codes in the compressed image with pixel values for use in display or exploitation of the data. This decompression is done in a two step process as shown in FIGURE 13. A compressed subframe consists of a 64 x 64 array of 12-bit codes. Each of these codes, during spatial decompression, is converted to a 4 x 4 block of decompressed pixels. Each pixel in this 4 x 4 block is an index into the color table, allowing it to have an RGB or monochromatic value. When decompressed, the output subframe is 256 x 256 pixels in size. The first 4 x 4 block is in the upper left hand corner of the subframe. The decompression continues across the first row through the first 64 codes. The 65th 12-bit code (/image code/ number 64) is used to decompress the first 4 x 4 block on the second row of the subframe. Decompression continues in this "row major" fashion until the entire subframe has been spatially decompressed. The output from the spatial decompression process described above is a 256 x 256 array consisting of indices to a 216 entry color table. A 217th entry (index 216) is a null value that represents "transparent" pixels (see 3.15) in a [frame file] that contains transparent pixels. The final decompression step involves color decompressing the subframe indices into their red, green blue (RGB) or monochromatic (M) pixel values. Each of the 217 entries in the CADRG color table contains an (RGB) and (M) pixel value that is in the range 0-255. Each pixel of a final RGB output image, therefore contains a 24-bit argument. However, because only 216 of the available 16.7 million colors are used in the subframe, the final image can be displayed with no color loss using 8-bits. Section 3.14.2 and 3.14.3 describe the steps of the decompression process in detail.

3.14.2 Spatial decompression. The CADRG compression section contains four [compression lookup table]s. Each of the tables contains the decompressed pixels for one of the rows of the compression vector. For a particular /image code/ *n*, there is an entry in each of the four tables. The resulting decompressed pixels from the four compression tables can be combined to form a single 4 x 4 block. A description of the logical steps to spatially decompress a 4 x 4 block is provided below.

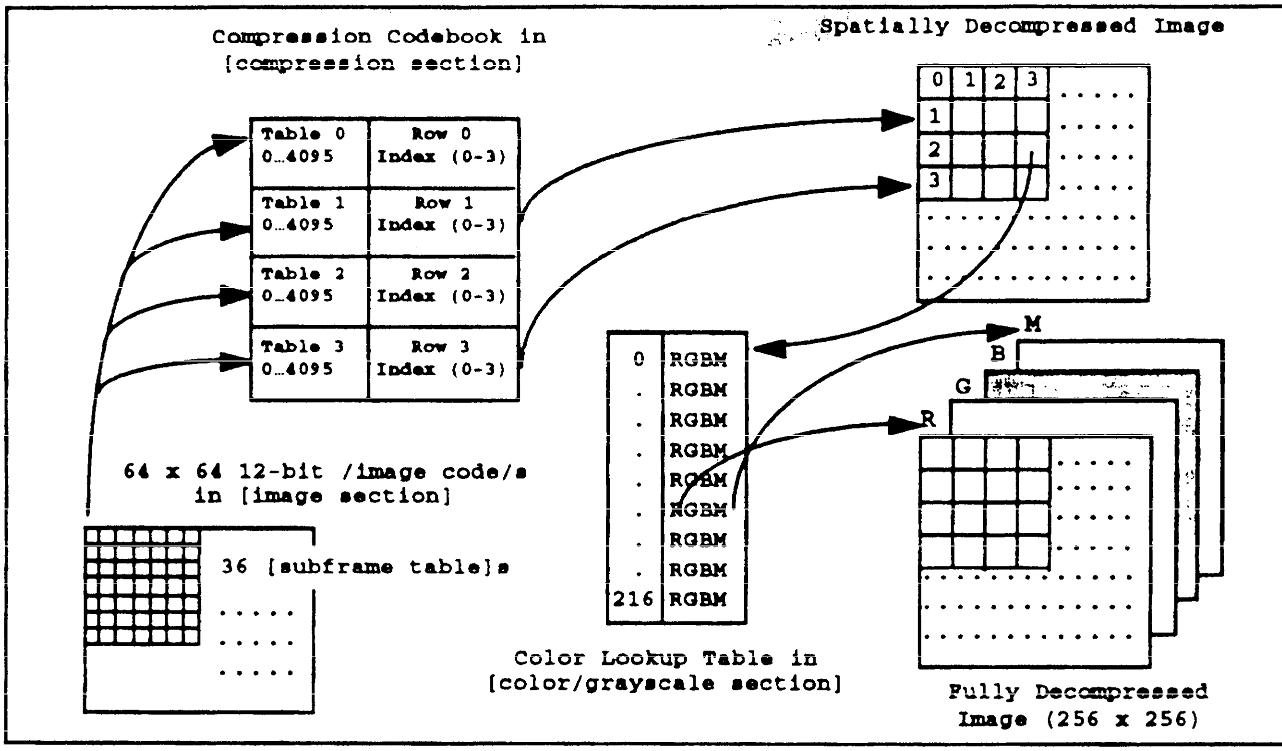

FIGURE 13. <u>Process Flow for CADRG Decompression</u>.

a. Each /image code/ has a value ranging from 0 to 4095, representing a particular code word. The /image code/ is used as an index into each of the 4 [compression lookup table]s. Each record of a [compression lookup table] contains 4 /compression lookup value/s. Therefore, the /image code/ indexes a 4 x 4 block of /compression lookup value/s (4 per row with 4 rows). As shown in FIGURE 14, each row of the compression codebook contains 4096 /compression lookup value/s for each row position. Each of these index values ranges from 0 to 215 (216 for transparent pixels) and represents an index into the color table.

b. If a compressed /image code/ in the [image section] contains the value n, then the 4 x 4 color table indices, represented as /compression lookup value/s in the [compression section], can be found first by using the [location section] to determine the starting byte of the [compression section]. If we let the offset to the start of first compression table be represented by A_1, then the location of the first 4 /compression lookup value/s for n would be located at the following byte positions within the [compression section]:

$$\text{Location for value 0, row 0} = A_1 + (4 \times n) \quad (1)$$
$$\text{Location for value 1, row 0} = A_1 + (4 \times n) + 1$$
$$\text{Location for value 2, row 0} = A_1 + (4 \times n) + 2$$
$$\text{Location for value 3, row 0} = A_1 + (4 \times n) + 3$$

c. The location of the next row of color index /compression lookup value/s would be offset 16,384 (4 x 4096) bytes from the start of the first row of values. If its offset was A_2 then the location of the second 4 values for n (the second row of 4 color table index values) would be at the following byte positions within the [compression section]:

$$\begin{aligned}
\text{Location for value 0, row 1} &= A_2 + (4 \times n) \\
\text{Location for value 1, row 1} &= A_2 + (4 \times n) + 1 \\
\text{Location for value 2, row 1} &= A_2 + (4 \times n) + 2 \\
\text{Location for value 3, row 1} &= A_2 + (4 \times n) + 3
\end{aligned} \tag{2}$$

d. The location of the color table index /compression lookup value/s for rows three and four would be similarly offset by 32,768 bytes and 49,152 bytes, respectively. It should be noted that the offset values for each of the [compression lookup table]s is included in the [compression lookup subsection]. Programmers should always examine the offset values to determine the starting location for each table.

e. To decompress the first 16 pixels of the map (4 x 4 section of the map located in the upper-left corner), the first 12-bit /image code/ (/image code/ number 0) would be used as an index to the 4 rows of 4 color table index /compression lookup value/s in the [compression section]. These 16 indices would be used as lookup values for the color table, and the 4 rows of 4 Red-Green-Blue or Monochrome values would be placed in the upper-left corner of the decompressed image. The decompression process continues across the columns and down the rows (see 3.14.1). In all, 4096 (64 x 64) groups of 4 x 4 pixels are placed into the output decompressed image for each subframe.

f. Although the description provided above can be used to decompress the image by sequentially decompressing the 4096 (64 x 64) compression vectors, the order of the decompression steps may be modified. Some applications may choose to decompress an entire row of the subframe at a time. This approach is made possible by the four separate compression tables for each image row.

3.14.3 Color decompression. The [color/grayscale table] in the [color/grayscale section] consists of either 216 or 217 entries, each of which contains 4 bytes. The first byte contains the red intensity level, the second byte contains the green intensity level, the third byte contains the blue intensity level and the fourth byte contains a monochrome (grayscale) intensity level, which is an arithmetic combination of red, green and blue intensity levels. The equation used to calculate the monochrome intensity level is:

$$\text{Monochrome Value} = 0.299(\text{Red}) + 0.587(\text{Green}) + 0.114(\text{Blue}) \tag{3}$$

[compression section]

Compression Algorithm ID,
Table Offsets, and Record Count Information

[compression lookup table]

Byte	Field Description	
A1	Row 0, Code 0,	Color Indices 0,1,2,3
A1+1	Row 0, Code 1,	Color Indices 0,1,2,3
A1+2	Row 0, Code 2,	Color Indices 0,1,2,3
A1+3	Row 0, Code 3,	Color Indices 0,1,2,3
..	....	
..	....	
A1+16380	Row 0, Code 4095,	Color Indices 0,1,2,3
A2	Row 1, Code 0,	Color Indices 4,5,6,7
A2+1	Row 1, Code 1,	Color Indices 4,5,6,7
A2+2	Row 1, Code 2,	Color Indices 4,5,6,7
A2+3	Row 1, Code 3,	Color Indices 4,5,6,7
..	....	
..	....	
A2+16380	Row 1, Code 4095,	Color Indices 4,5,6,7
A3	Row 2, Code 0,	Color Indices 8,9,10,11
A3+1	Row 2, Code 1,	Color Indices 8,9,10,11
A3+2	Row 2, Code 2,	Color Indices 8,9,10,11
A3+3	Row 2, Code 3,	Color Indices 8,9,10,11
..	....	
..	....	
A3+16380	Row 2, Code 4095,	Color Indices 8,9,10,11
A4	Row 3, Code 0,	Color Indices 12,13,14,15
A4+1	Row 3, Code 1,	Color Indices 12,13,14,15
A4+2	Row 3, Code 2,	Color Indices 12,13,14,15
A4+3	Row 3, Code 3,	Color Indices 12,13,14,15
..	....	
..	....	
A4+16380	Row 3,Code 4095,	Color Indices 12,13,14,15

FIGURE 14. Example File Layout of [compression section].

a. Each byte that resulted from the spatial decompression process is used as an index into the color table. The result of each lookup procedure is a four-byte value, which represents the red, green, and blue (RGB) color intensities for a particular pixel, and a one-byte monochromatic (grayscale) value (see EQUATION 3) for a particular pixel in the subframe. In general, either the RGB or the monochromatic value is used to display the image.

b. Each byte in the spatially decompressed matrix will be an integer in the range 0-215(216). The values are used as lookup values into the color table. The 216(217) entries in the color table contain RGB and monochrome values in the range 0 - 255, arranged as shown in FIGURE 15. The entries in the color table represent RGBM values for pixels in the digitized map that represent digitized map data. Entry 216 is reserved for "transparent" pixels, for cases where the data is missing or not available at the given geographic location. The RGBM values in the CADRG color table for the 217th entry (index 216, for transparent pixels) are 0, 0, 0, 0.

c. A value of *m* in the spatially decompressed subframe can be used to determine the RGB values of a pixel in the output image first by using the [location section] to determine the starting byte of the [color/grayscale section]. If we let *B* represent the offset to the [color/grayscale section], then the location of the RGBM values for *m* would be located at the following byte position within the [color/grayscale section]:

$$\text{Location for RGBM Value} = B + (4 \times m) \qquad (4)$$

d. To reconstruct the image, each 1-byte element from the spatially decompressed matrix is replaced by the RGB or M values that were derived during color decompression. The RGB or monochrome matrix obtained from this step becomes the decompressed CADRG subframe.

[color/grayscale section]

Color Table Information, including Table Offsets and Record Counts

[color/grayscale table]s

Byte	**Field Description**		
B	**Index 0**	**R G B M**	
B+4	**Index 1**	**R G B M**	
B+8	**Index 2**	**R G B M**	**RGB and Grayscale Indices**
B+12	**Index 3**	**R G B M**	
B+16	**Index 4**		
..	....		
..	....		
B+860	**Index 215**	**R G B M**	
B+864	**Index 216**	**0 0 0 0**	**Transparent Index**

FIGURE 15. Example File Layout of [color/grayscale section].

3.15 CADRG Update Files. CADRG files are compliant with the Raster Product Format and therefore they contain a configuration control mechanism to support updating. The mechanism exploits the subframe aspects and the [replace/update section] of RPF.

To avoid redundancy, and because some of the sections and subsections within RPF are optional, a CADRG update file does not contain all of the information that a full CADRG file contains. The following paragraphs detail which sections are necessary within the update file and which optional sections are not recorded.

3.15.1 Header Section. The [header section] of a CADRG update file shall conform to section 3.12.1 of this document and MIL-STD-2411. In addition, the <new/replace/update indicator> ::= 2 to indicate that the file is an update file.

3.15.2 Location Section. The [location section] of a CADRG update file shall conform to section 3.12.2 of this document and MIL-STD-2411.

3.15.3 Coverage Section. The [coverage section] shall not be included in the CADRG update file. All information required for the [coverage section] exists in the file which is being updated.

3.15.4 Compression Section. The [compression section] is not included in the CADRG update file. All information needed to decompress the image data of the update file exists in the file which is being updated.

3.15.5 Color/grayscale Section. Only part of the [color/grayscale section] is necessary in an update file. The [colormap subsection] which contains updated histograms is included. In addition, the update file includes the [color/grayscale element group]; by design, the [color/grayscale element group] included in the update file is identical to the [color/grayscale element group] in the parent file. The [color/grayscale section subheader] is included in the update file because it contains information needed to decode the [colormap subsection] of the update file. The [color converter subsection] is not included in the CADRG update file.

3.15.6 Image Section. The [image section] is necessary in an update file. The [spatial data subsection] contains all subframes to be replaced in the CADRG file to be updated. The [mask subsection] of the update file defines the spatial location of those new subframes. The [image description subheader] and the [image display parameter subheader] are also included in the CADRG update file.

3.15.7 Attribute Section. The [attribute section] of an update file contains new attribute information about the file and is therefore included.

3.15.8 Replace/Update Section. The [replace/update section] is included in an update file and is as defined in 3.12.8. and MIL-STD-2411.

3.16 Transparent pixels. Subframes that are partially filled by the image coverage area are padded with transparent pixels color index code (set to 216) during data production. A 4 x 4 kernel in a subframe that contains at least one transparent pixel is replaced by the 12-bit /image code/, represented by index 4095. This entry represents a transparent kernel in any frame that contains transparent pixels. If no transparent pixels are present then index 4095 will be used for colors. The last <color/grayscale element> (index 216) in the [color/grayscale table] is set to 0 (black) to represent a transparent "color." If application software encounters index 4095 in a frame containing transparent pixels, it may color decompress to display black, or remap the transparent kernel to a system-specific transparent color. In such a case, the /compression lookup value/s in the index 4095 kernel point to the index 216 <color/grayscale element>. User software can map this value to a system-specific transparent pixel color. MIL-STD-2411 defines two fields, the /transparent output pixel code/ and the <transparent output pixel code length> for use in frames with transparent pixels. For CADRG, the /transparent output pixel code/ shall be set to 216 if there are transparent pixels and the <transparent output pixel code length> field shall be set to 8, indicating that the /transparent output pixel code/ field is 8 bits long. If there are no transparent pixels, the <transparent output pixel code length> field shall be set to 0 and the /transparent output pixel code/ is not recorded.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of paragraphs 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. First article inspection (see 4.3).

b. Quality conformance inspection (see 4.4).

4.3 First article inspection. When a first article inspection is required (see 3.1 and 6.2), it shall be examined for defects specified in 4.4.1 and tested as specified in 4.4.2.

4.4 Quality conformance inspection. The CADRG frame files shall be examined for defects and errors as specified in 4.4.1. Required corrections shall be made to all files before being sent to the next production stage. Defects detected during the inspection of the frame files shall be evaluated by DMA for criticality an suitable corrective action.

4.4.1 Tests. The following classes of defects and errors will be tested for:

a. Horizontal Accuracy. Frame files will be inspected to ensure that a horizontal accuracy of plus or minus one-half pixel with respect to the source ADRG is maintained.

b. Visual Appearance. Each frame file will be inspected for overall color appearance. Each frame file will be inspected for feature loss due to color appearance.

c. Attribute Data. Frame files will be inspected to ensure the accuracy of textual attribute data.

d. Standards Compliance. Each frame file will be inspected to ensure compliance with ISO 9660, MIL-STD-2411, MIL-STD-2500, and this specification.

4.5 Review of construction records. Records about the construction of the frame files shall be maintained. The records shall document sources, decisions regarding reconciliation of conflicting data, etc. Frame file records/construction histories shall be reviewed concurrently with visual examinations (see 4.4.1) to ensure that proper cartographic procedures have been followed.

5. PACKAGING

5.1 General. CADRG shall be distributed on CD-ROMs, distributed in clear plastic cases (also known as "jewel boxes"). Each CD-ROM shall be labeled to indicate the cartographic contents of the CD-ROM, map projection, map scale, security restrictions (if any), distribution limitations, producer (Government agency or contractor), library number, DMA stock number bar code, edition number and date. The jewel boxes shall contain the information printed on the CD-ROM, plus a location diagram, and an information booklet. The printing and finishing requirements are specified in DMA Technical Instruction TI/2DJ/001.

5.1.1 Media labeling. CADRG CD-ROMs will be color coded to indicate the highest level of classification of the contents of the volume. FIGURES 16a and 16b shows possible label formats for the unclassified and classified CD-ROMs. The label format for specific CD-ROMs will depend upon the contents of the CD-ROM.

a. UNCLASSIFIED labels will have a white background, and the text and symbols shall be overprinted in black.

b. CONFIDENTIAL labels will have a dark blue background, and the text and symbols shall be overprinted in white.

c. SECRET labels will have a red background, and the text and symbols shall be overprinted in white.

d. TOP SECRET labels will have an orange background, and the text and symbols shall be overprinted in black.

5.1.2 Location diagrams. The jewel-box liner (also known as a tray card) may include a Location Diagram, which is a graphic depiction (see FIGURE 17) of the geographic location of the cartographic contents of the interchange volume.

5.1.3 Information booklet. An information booklet will provide general information about the contents of the CD-ROM, handling instructions, user and distribution information, and DMA points of contact. FIGURE 18 shows the format of the information booklet covers.

5.1.4 Catalog indexing. Each CD-ROM in the CADRG library shall be indexed to facilitate configuration management, including updates, additions, and replacements. The format convention of the alphanumeric value of a bar-coded DMA stock number for standard CADRG distribution is a fifteen character identifier according to the following description:

a. For all series, the first five positions are always "CDRG<blank>".

b. The remaining ten characters are defined by the particular series (see 5.4.1).

1. GNC/JNC: "GNCJNCn<blank><blank><blank>", where n is "N" for the northern hemisphere, or "S" for the southern hemisphere.

2. ONC/TPC: "ONCTPCnn<blank><blank>", where nn is a number between 01 and 20 designating the pre-defined geographical area.

3. JOG: "5aabbnnmm<blank>", where 5 designates this as a JOG volume and aabbnnmm designates a bounding rectangle: aa is the JOG band nearest the equator, bb is the JOG band farthest from the equator, nn is the left JOG column, and mm is the right JOG column.

4. TLM/City Graphics/Combat Charts: "7aannmmssr", where 7 designates this as a TLM volume and aannmmss is the block covered (aa is the JOG band, nn is the left JOG column, mm is the right JOG column, and ss indicates the subblock (01-04)). The r is usually a blank. However, when the addition of city graphics and combat charts causes the subblock to exceed the volume of a single distribution media (i.e., CD-ROM), the subblock will further be divided into regions. The r will then be an alpha character (A-Z).

5. For special packages (see 5.4.2) the last ten characters will be a name representative of the region or purpose covered by the volume, i.e. RPFSAMPLER, SWRANGES<blank><blank>, SOMALIA<blank><blank><blank>, etc.

5.2 Packaging. Packaging shall be level C (see 6.2) unless otherwise specified. This packaging provides minimum protection, and is needed to protect material under known favorable conditions. The following criteria determine the requirements for this degree of protection:

a. Use or consumption of the item at the first destination.

b. Shock, vibration, and static loading during the limited transportation cycle.

c. Favorable warehouse environment for a maximum of 18 months.

d. Effects of environmental exposure during shipment and in transit delays.

e. Stacking and supporting superimposed loads during shipment and temporary storage.

5.3 Marking. In addition to any special markings required by the contract or order, markings shall be in accordance with requirements of MIL-STD-129 for military levels of protection.

5.4 Distribution. Interchange volumes may include any reasonable combination of the CADRG and other RPF data on the same volume. In addition, CADRG data from multiple scales may be included on a volume.

5.4.1. Normally, CADRG will be distributed (on CD-ROMs) without other RPF data. Standard packaging of CADRG by DMA will be as follows:

a. In support of aeronautical combat operations, CADRG will be packaged in three distinct groupings: GNC and JNC, ONC and TPC, and JOG.

b. In support of ground combat operations, CADRG will be packaged based on TLM coverage. The volume will include the TLM along with associated JOGs, City Graphics, and Combat Charts. ONC coverage will be provided as an overview.

c. Other CADRG products (nautical charts, classified materials, etc.) will be packaged by type and may be either uniform or mixed in scale.

d. CADRG of non-DMA charts will generally be packaged in a manner corresponding to their DMA counterparts. For example, UK LFC and TFC would be packaged as if they were TPC and JOG.

5.4.2 In support of crisis, special, and/or reoccurring broad-based user requirements, CADRG will be geopackaged vertically (all scales) and with other RPF products covering discrete geographic regions. For example, data sets can be identified for test ranges, major training centers, or crisis areas where integrated datasets with mixed data types and scales are needed by large numbers of users.

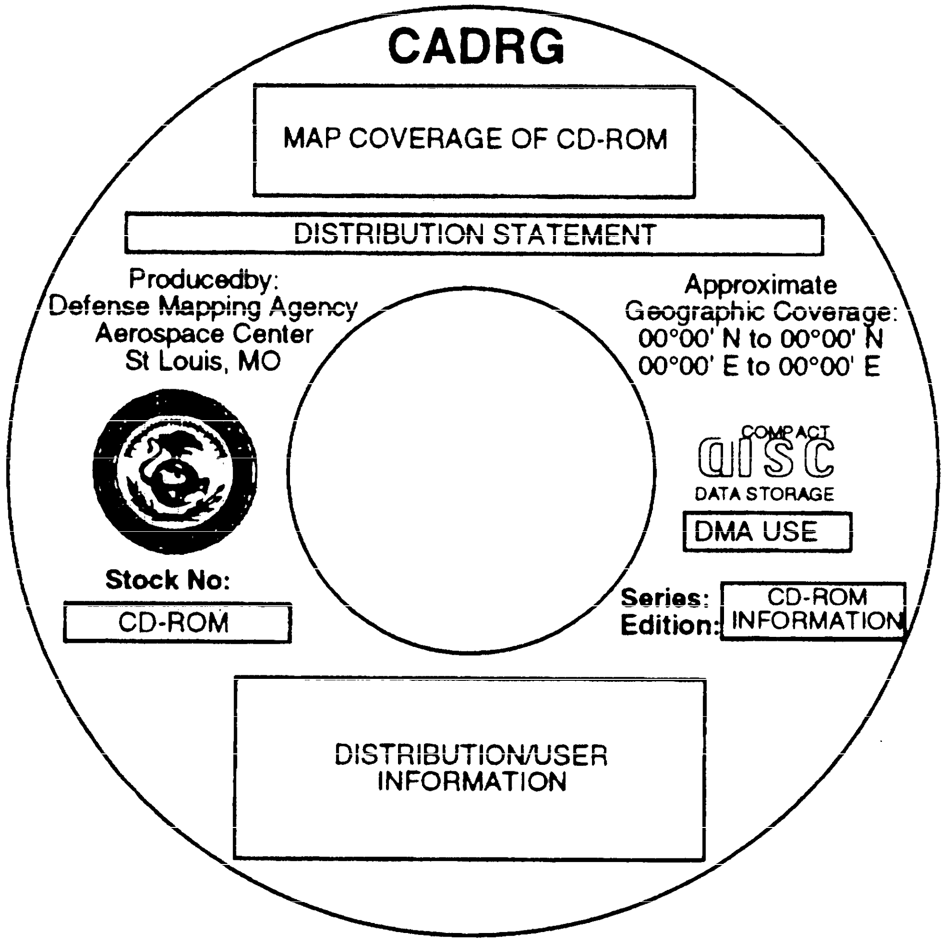

FIGURE 16a. Example Label Format for Unclassified CD-ROMs.

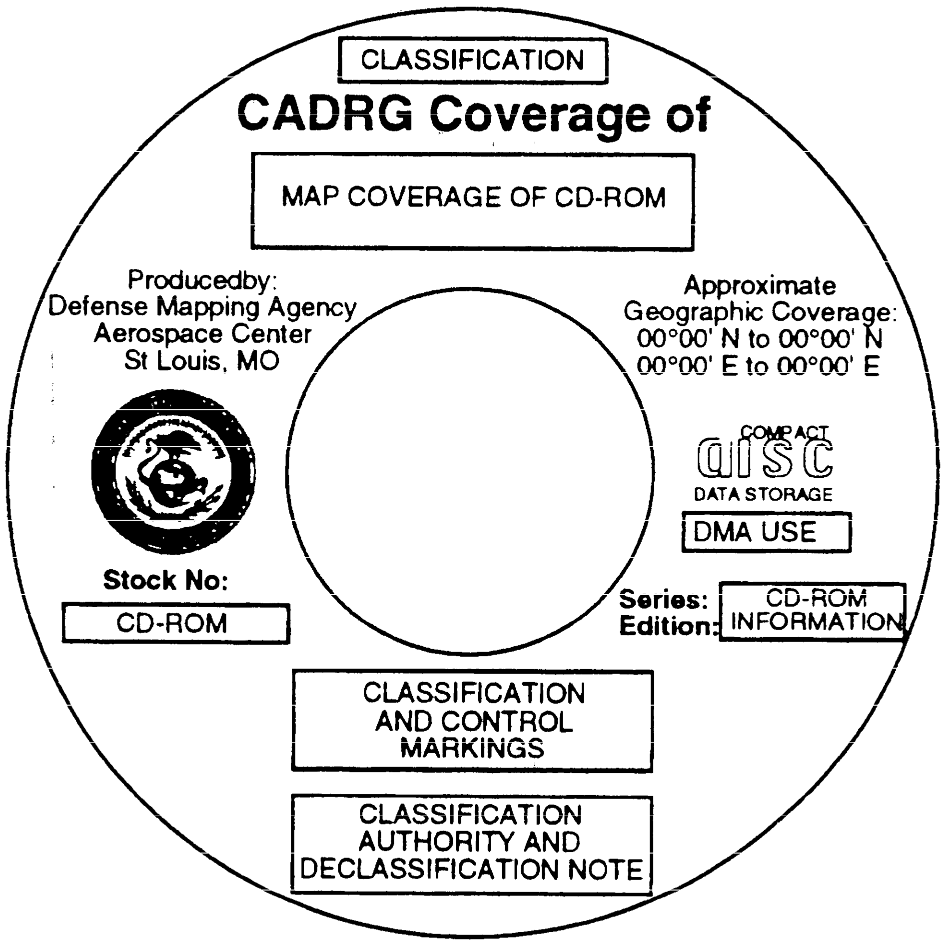

FIGURE 16b. Example Label Format for Classified CD-ROMs.

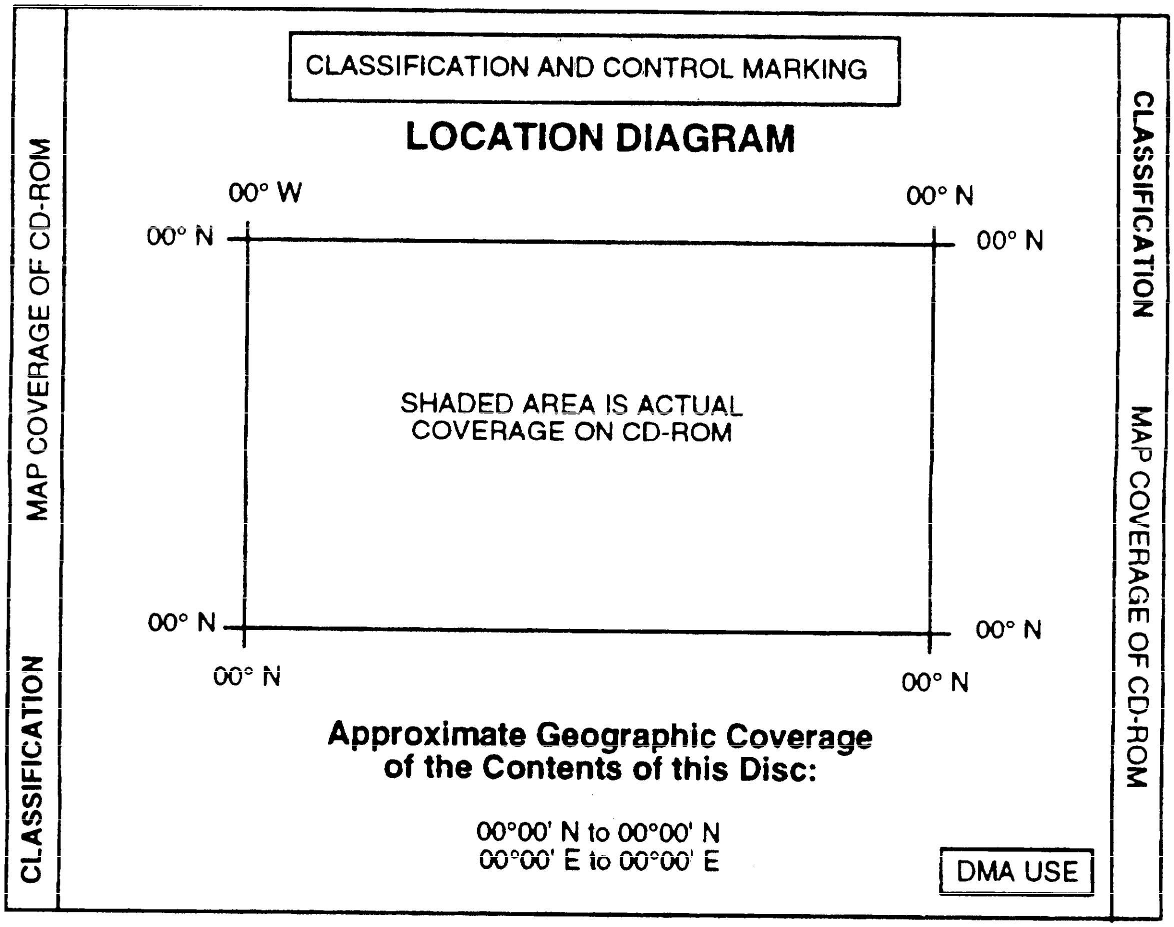

FIGURE 17. Example Format for Location Diagram.

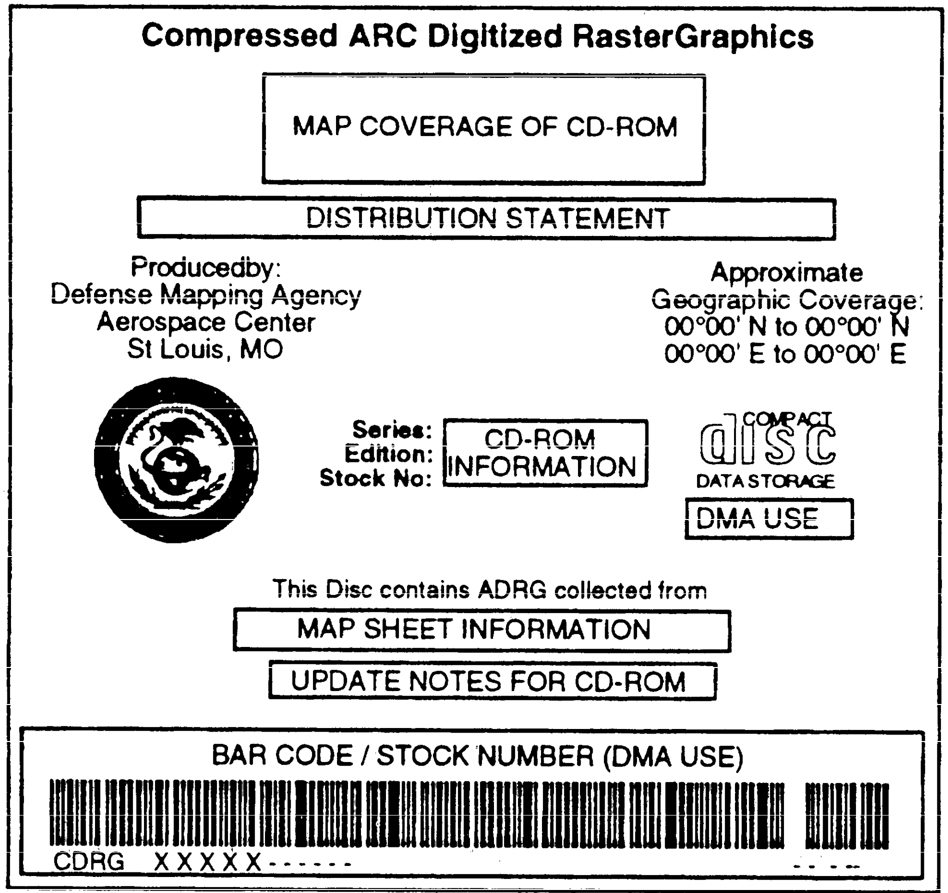

FIGURE 18. Example Format for Information Booklet.

6. NOTES
(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This specification is intended to provide guidelines for the preparation and use of CADRG data to support various weapons, C3I theater battle management, mission planning, and digital moving map systems. This specification is a new publication and does not supersede any other publication.

a. CADRG image data is of appropriate size and quality for use in military command and control systems, ground-based force to unit-level mission planning systems, and aircraft cockpit "moving map" displays. The post-reduction filtering scheme emphasizes legibility of text and contour lines to ensure that displayed and printed digital maps are readable and distinct. CADRG is intended to satisfy the needs of a broad range of users in its compression ratio, display and print quality and displayed screen size.

b. The 55:1 reduction in size of CADRG compared to source ADRG offers distinct operational, logistical, and supportability benefits to many users of digitized map/chart and imagery data. It permits the same datasets to be used for both ground-based and aircraft cockpit displays, offers significant savings in media storage/transportation and peripherals (i.e., hard disk) costs, results in faster data loading times and requires less frequent reloading of hard disks from media. It also allows multiple scale and product types to be placed on interchange media for geographic areas of interest.

c. CADRG [frame file]s may be physically formatted within a NITF message.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of this specification.

b. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2.2).

c. When a first article is required (see 3.1, 4.3, and 6.3).

d. Levels of packaging (see 5.2).

6.3 First article. When a first article is required, it shall be inspected and approved under appropriate provisions of FAR 52.209. The contracting officer shall specify the appropriate type of first article and the number of units to be furnished. The contracting officer shall also include specific instructions in acquisition documents regarding arrangements for selection, inspection, and approval of the first article.

6.4 Acronyms.

ADRG	ARC Digitized Raster Graphics
ANSI	American National Standards Institute
ARC	Equal Arc-Second Raster Chart
ATC	Air Target Chart
CADRG	Compressed ADRG
CD-R	Compact Disk - Recordable
CD-ROM	Compact Disk – Read Only Memory
DIS	Draft ISO Standard
DMA	Defense Mapping Agency
FIPS PUB	Federal Information Processing Standard Publication
GNC	Global Navigation Chart
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IFS	Independent File System
ISO	International Standards Organization
JNC	Jet Navigation Chart
JOG	Joint Operations Graphic
JOG-A	Joint Operations Graphic – Air
JOG-R	Joint Operations Graphic – Radar
LFC	Low Flying Chart (UK)
ONC	Operational Navigation Chart
RPF	Raster Product Format
RGB	Red–Green–Blue
TFC	Transit Flying Chart (UK)
TLM	Topographic Line Map
TPC	Tactical Pilotage Chart
VQ	Vector Quantization
WGS-84	World Geodetic System – 1984

6.5 International standardization agreements. Certain provisions of this specification may be subject to international standardization agreements. When amendment, revision, or cancellation of this specification is proposed that will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

6.5.1 International Standardization Agreements (STANAGs). STANAG 2211, "Geodetic Datums, Spheroids, Grids, and Cell References."

6.5.2 Quadripartite Standardization Agreements (QSTAGs). This section is not applicable to this specification.

6.5.3 Air Standardization Coordinating Committee (ASCC) Agreements. This section is not applicable to this specification.

6.5.4 International MC&G Agreements. This section is not applicable to this specification.

6.5.5 Executive Orders. This section is not applicable to this specification.

6.5.6 InterAgency Agreements. This section is not applicable to this specification.

6.6 Subject term (key word) listing.

ADRG
ARC
CD-ROM
NITF
Pixel
VQ

APPENDIX

10. SCOPE

10.1 Scope. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance. Appendix 30 provides the coordinate transformation relationships between the latitude and longitude of points and the rows and columns of subframes and pixels within a [frame file]. It also defines a conceptual grid of [frame file]s that can be used by producers and receivers to configuration manage datasets, and it provides a naming convention to be used for many scales of maps. Appendix 40 provides information about the sizes of the sections of a [frame file] and provides a typical example with binary and decimal or logical values for that example. Appendix 50 lists CADRG attributes, and data types. The possible data codes for the attributes are defined in MIL-STD-2411-1. Appendix 60 describes the method of determining the possible number of frames and subframes per zone at each scale, and provides tables of these values for a number of scales.

20. APPLICABLE DOCUMENTS

This section is not applicable to this APPENDIX.

30. COORDINATE TRANSFORMATIONS

30.1 References for the ARC system projection. Non-polar zone equations are based on the Equirectangular projection. Polar zone equations are based on the Azimuthal Equidistant projection, polar aspect, spherical form. Coordinate values are in the range $-180° \le$ longitude $(\lambda) \le +180°$ and $-90° \le$ latitude $(\phi) \le +90°$. TABLES 3 and 4 list the parameters used, respectively, for the non-polar and polar coordinate computations.

a. For the polar case, the relationship between the pixel locations, and geodetic latitude and longitude shall adhere to the convention defined in MIL-A-89007 (sections 30.3.3 and 30.3.4). Specifically, pixels in the polar region are mapped into a pixel coordinate system that is centered at the pole itself, to facilitate the transformations from pixel coordinates to latitude and longitude.

TABLE 3. Non-Polar Coordinate Conversion Parameters.

Parameter	Description
(r_{Fz}, c_{Fz})	Row and column number of a CADRG frame in zone z for scale s.
(R, C)	Maximum number of rows and columns within contiguous grid for zone z and scale s.
n_{sz}	Cumulative frame number within zone z at scale s.
(r_{pF}, c_{pF})	Row and column number of a pixel within a frame.
(ϕ, λ)	Latitude, longitude of point in WGS-84 coordinates.
(ϕ_F, λ_F)	Latitude, longitude of frame origin for non-polar.
(ϕ_{sz}, λ_z)	Latitude, longitude of ARC non-polar origin of zone z and scale s (λ_z = -180°).
A_{sz}	East-West Pixel Constant for scale 1:S and zone z.
B_S	North-South Pixel Constant for scale 1:S in all zones.
P_F	Number of pixels in each dimension of a frame ::=1536.

TABLE 4. Polar Coordinate Conversion Parameters.

Parameter	**Description**
(r_F, c_{Fz})	Row and column number of a CADRG frame in a polar zone
(r_{PF}, c_{PF})	Row and column number of a pixel within a frame.
(ϕ, λ)	Latitude and longitude of a point in WGS-84 coordinates.
$(\langle X\rangle, \langle Y\rangle)$	Projection coordinates of a pixel with respect to pole.
C_S	Polar Pixel Constant for scale 1:S divided by 360°.
P_F	Number of pixels in each dimension of a frame ::=1536.
R	Number of pixels from a pole to side of frame structure

b. For very large scale maps or charts (e.g., greater than 1:7800, see section 30.6) discrete [frame file]s will be produced as appropriate. For all small scales, a theoretical gridding of contiguous frames shall be defined by the producers for each scale and zone. Some frames within these contiguous grids will never be produced (for example, if no source map or chart exists that includes the predefined area of the entire frame) and some frames will be only partially filled (for example, if the source map or chart exists for only a portion of the predefined area of the frame). This contiguous grid is for configuration management of the [frame file]s and the frame naming convention (see section 30.6). Within each zone grid, an absolute frame numbering is defined within each zone at each scale. The frame numbers start from 0 at the left, southernmost corner of each zone, increase in row-major order left to right for each row, and end at the right, northernmost corner of the zone.

c. The numbers of frame and subframe rows and columns, the pixel constants, and the exact latitudinal zone extents are provided in APPENDIX section 60 (TABLES 8 thru 14).

30.2 Non-polar latitude and longitude of a CADRG frame pixel. The following equations may be used to obtain the latitude

(ϕ) and longitude (λ) of a pixel. The latitude of a pixel is a function of the frame row number (see 3.5.3.b) and pixel row number within the frame. The longitude of a pixel is a function of the frame column number (see 3.5.3.b) for its zone, and pixel column number within the frame (see FIGURE 19). The latitude and longitude of a pixel can be determined relative to the origin (ϕ_F, λ_F) of a frame (i.e., upper-left corner latitude and longitude) as provided in the [coverage section]. The latitudes and longitudes used in the conversion equations are signed real numbers with a negative number signifying southern or western hemisphere, respectively.

30.2.1 Pixel row coordinate to latitude coordinate equation

$$\phi = \phi_F - \frac{90°}{B_S} * r_{PF} \tag{5}$$

30.2.2 Pixel column coordinate to longitude coordinate equation

$$\lambda = \lambda_F + \frac{360°}{A_{SZ}} * c_{PF} \tag{6}$$

30.3 Non-polar frame pixel coordinates of a geographic point. The following equations can be used to obtain the frame and pixel row and column numbers (r_{FZ}, C_{FZ}, r_{FP} and c_{FP}) of a point, given the latitude and longitude of the point (see FIGURE 19). The zone of the point is determined by zone extents with overlap (APPENDIX section 60, TABLES 8 thru 14).

30.3.1 Latitude equations. Calculate the frame row within the zone,

$$r_{FZ} = \mathrm{INT}\left\{ \frac{\phi - \phi_Z}{90°} * \frac{B_S}{P_F} \right\} \tag{7}$$

and then the latitude of the frame origin (ϕ_F, the latitude of the northwest corner of the frame),

$$\phi_F = \frac{90°}{B_S} * P_F * (r_{FZ} + 1) + \phi_Z \tag{8}$$

and finally the pixel row with respect to the frame origin,

$$r_{PF} = \frac{\phi_F - \phi}{90°} * B_S \tag{9}$$

30.3.2 Longitude equations. Calculate the frame column within the zone,

$$c_{Fz} = \text{INT}\left\{ \frac{\lambda - \lambda_z}{360^\circ} * \frac{A_{sz}}{P_F} \right\} \tag{10}$$

where: $90^\circ/B_s$ ::= <latitude/vertical interval> for pixels

$360^\circ/A_{sz}$ ::= <longitude/horizontal interval> for pixels

and ϕ_F ::= <northwest/upper left latitude> of frame

λ_F ::= <northwest/upper left longitude> of frame

and then the longitude of the frame origin (λ_F, the longitude of the northwest corner of the frame),

$$\lambda_F = \frac{360^\circ}{A_{sz}} * P_F * (c_{Fz} + \lambda_z \tag{11}$$

and finally the pixel column with respect to the frame origin,

$$c_{PF} = \frac{\lambda - \lambda_F}{360^\circ} * A_{sz} \tag{12}$$

30.4 Polar latitude and longitude of a CADRG frame pixel.

30.4.1 North polar region. Given the projection coordinates of a point (<X>, <Y>) with respect to the north pole, its latitude and longitude in degrees shall be computed as follows (see FIGURE 20):

$$\phi = 90^\circ - \left[\frac{\sqrt{\langle X\rangle^2 + \langle Y\rangle^2}}{C_s} \right] \tag{13}$$

$$\lambda = \text{ACOS}\left[\frac{-\langle Y\rangle}{\sqrt{\langle X\rangle^2 + \langle Y\rangle^2}} \right] \quad \text{for } \langle X\rangle > 0 \tag{14}$$

$$\lambda = -\text{ACOS}\left[\frac{-\langle Y\rangle}{\sqrt{\langle X\rangle^2 + \langle Y\rangle^2}} \right] \quad \text{for } \langle X\rangle < 0 \tag{15}$$

where: $\lambda = 180^\circ$ for $[\langle X\rangle = 0$ and $\langle Y\rangle > 0]$;

and $\lambda = 0^\circ$ for $[\langle X\rangle = 0$ and $\langle Y\rangle \le 0]$; and

$$0^\circ \le \text{ACOS}\left[\frac{-\langle Y\rangle}{\sqrt{\langle X\rangle^2 + \langle Y\rangle^2}} \right] \le 180^\circ.$$

30.4.2 South polar region. Given the projection coordinates of a point (<X>, <Y>) with respect to the south pole, its latitude and longitude in degrees shall be computed as follows (see FIGURE 21):

$$\phi = -90^\circ + \left[\frac{\sqrt{<X>^2 + <Y>^2}}{C_S}\right] \tag{16}$$

$$\lambda = \mathrm{ACOS}\left[\frac{<Y>}{\sqrt{<X>^2 + <Y>^2}}\right] \quad \text{for } <X> > 0 \tag{17}$$

$$\lambda = -\mathrm{ACOS}\left[\frac{<Y>}{\sqrt{<X>^2 + <Y>^2}}\right] \quad \text{for } <X> < 0 \tag{18}$$

where: $\lambda = 0^\circ$ for $[<X> = 0$ and $<Y> \geq 0]$;

and $\lambda = 180^\circ$ for $[<X> = 0$ and $<Y> < 0]$; and

$$0^\circ \leq \mathrm{ACOS}\left[\frac{<Y>}{\sqrt{<X>^2 + <Y>^2}}\right] \leq 180^\circ.$$

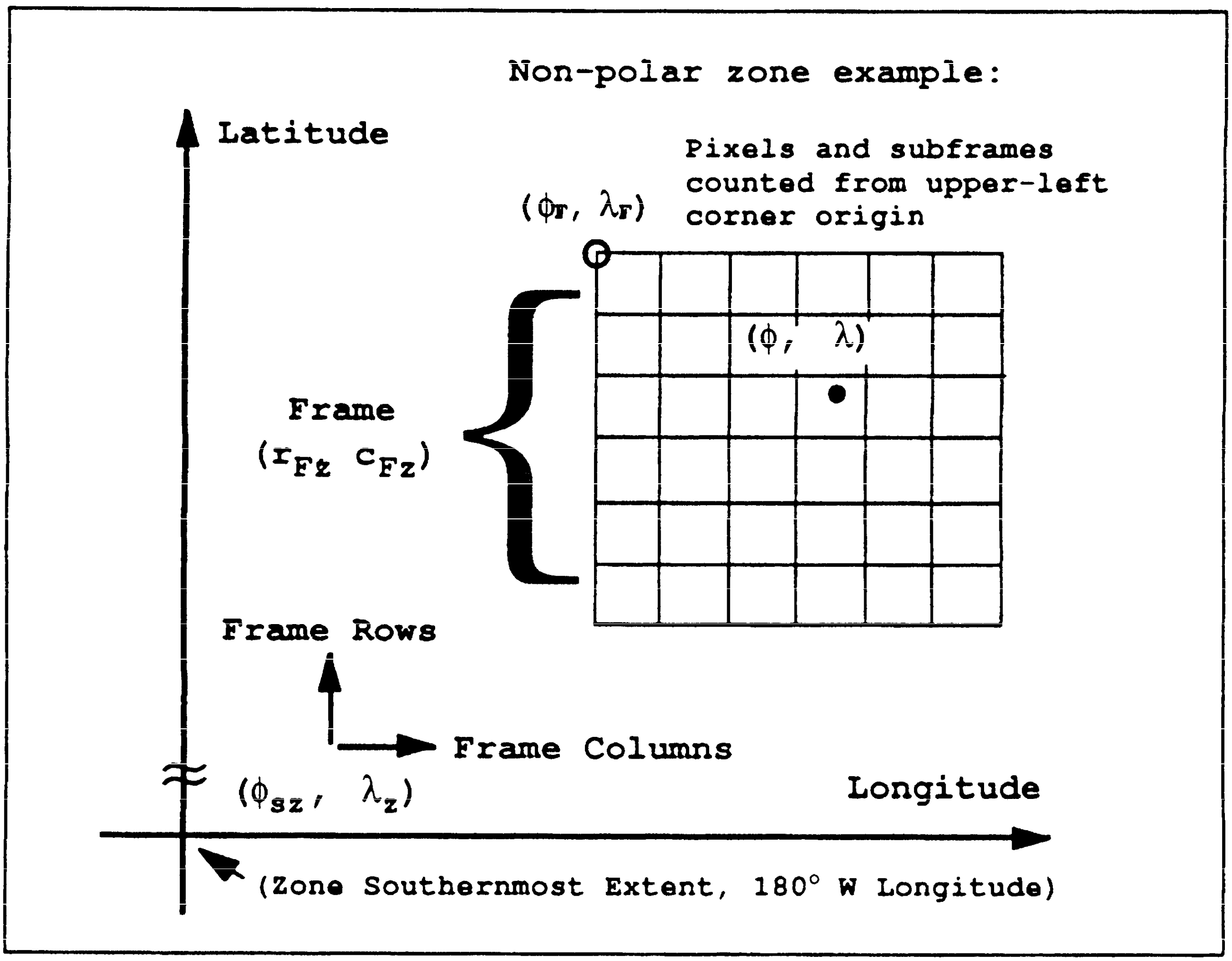

FIGURE 19. Coordinate Transformation in Non-Polar Zones.

30.5 Polar frame pixel coordinates of a geographic point.

30.5.1 North polar region. Given the latitude and longitude of point (ϕ, λ), its projection coordinates (<X>, <Y>) shall be computed as follows (see FIGURE 20):

$$\langle X\rangle = C_S * (90^\circ - \phi) * \mathrm{SIN}(\lambda) \tag{19}$$

$$\langle Y\rangle = -C_S * (90^\circ - \phi) * \mathrm{COS}(\lambda) \tag{20}$$

The coordinates <X> and <Y> are given with respect to the north pole as an origin of a rectangular coordinate system. It is useful to translate the coordinates of the point to the CADRG frame structure. The frame structure has its origin in its lower left corner. The expressions for the frame row and column, the subframe row and column, and the pixel position with respect to the lower left corner of the frame structure are computed as follows:

$$r_F = \mathrm{INT}\left\{\frac{\langle Y\rangle + R}{P_F}\right\} \tag{21}$$

$$c_F = \mathrm{INT}\left\{\frac{\langle X\rangle + R}{P_F}\right\} \tag{22}$$

$$r_{PF} = [P_F - 1] - \mathrm{INT}\left\{\left[\left(\frac{\langle Y\rangle + R}{P_F}\right) - r_F\right] * P_F\right\} \tag{23}$$

$$c_{PF} = \mathrm{INT}\left\{\left[\left(\frac{\langle X\rangle + R}{P_F}\right) - c_F\right] * P_F\right\} \tag{24}$$

The constant R is calculated by finding the number of frames on a side of the frame structure (see 60.2.3), dividing by two and multiplying by the number of pixels (1536) per frame side.

30.5.2 South polar region. Given the latitude and longitude of point (ϕ, λ), its projection coordinates (<X>, <Y>) shall be computed as follows (see FIGURE 21):

$$\langle X\rangle = C_S * (90 + \phi) * \mathrm{SIN}\ (\lambda) \tag{25}$$

$$\langle Y\rangle = C_S * (90 + \phi) * \mathrm{COS}\ (\lambda) \tag{26}$$

The coordinates <X> and <Y> are given with respect to the south pole as an origin of a rectangular coordinate system. Since the frame coordinate system has its origin in the lower left corner in an identical scheme as the north polar region, all frame, subframe and pixel calculations are identical to the north polar calculations.

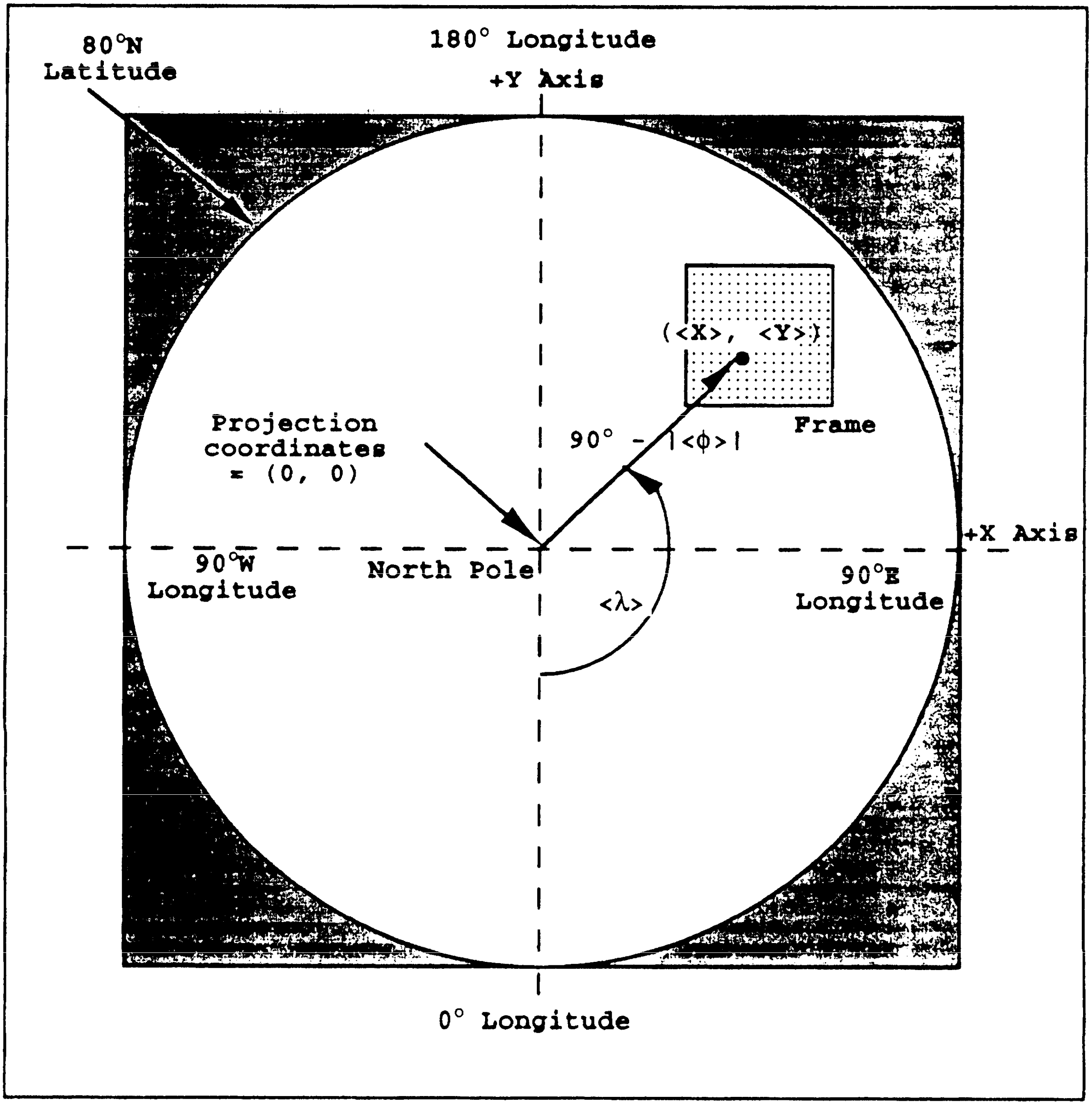

FIGURE 20. Coordinate Transformation in North Polar Region.

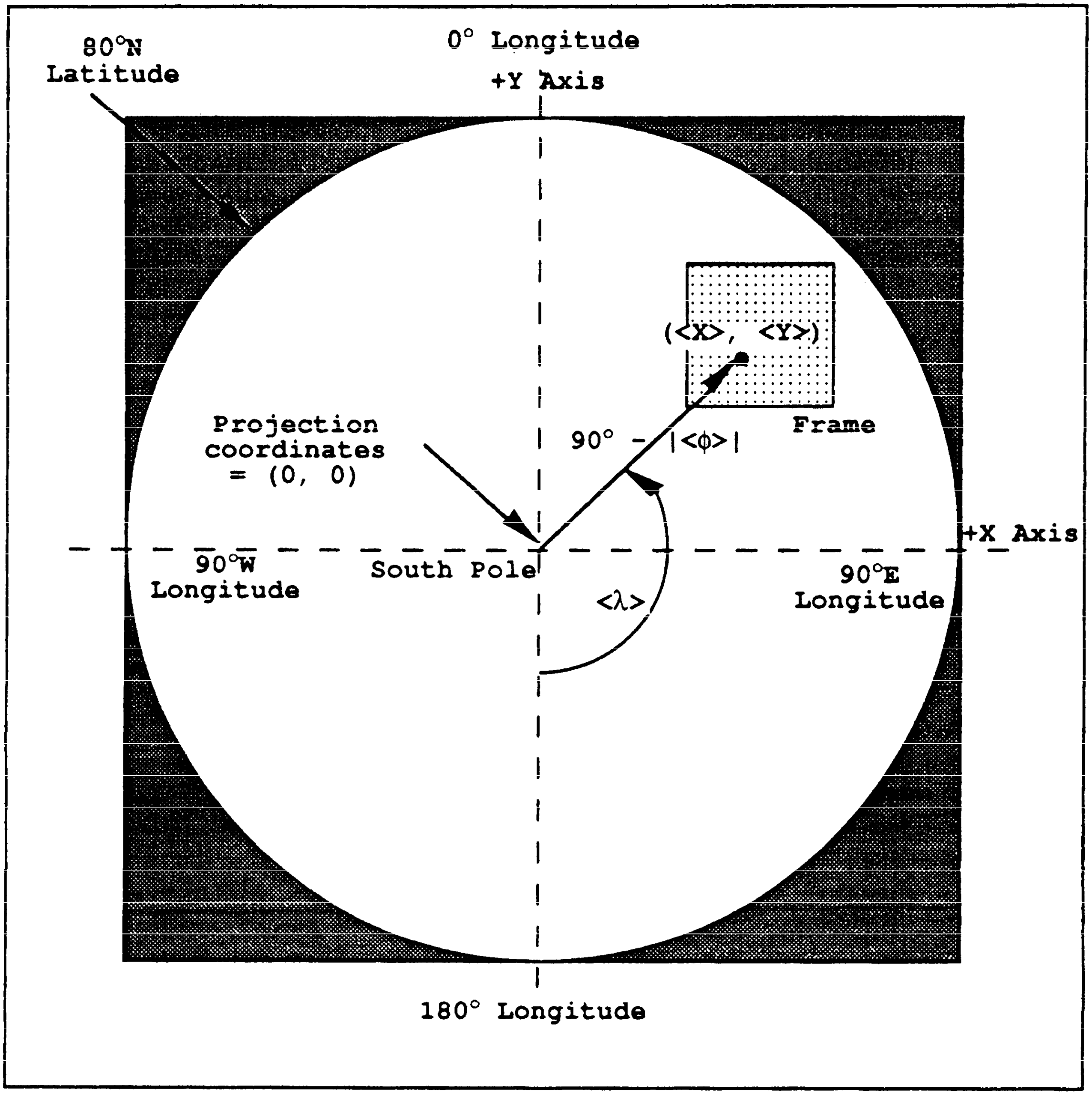

FIGURE 21. Coordinate Transformation in South Polar Region.

30.6 <u>Frame naming convention</u>. The frame naming convention for non-standard miscellaneous large-scale maps and charts shall conform to MIL-STD-2411, and be assigned by the producer. The naming convention for all standard small-scale maps and charts, where it is intended for producers to provide contiguous [frame file] coverage (see section 30.1 of the APPENDIX) shall conform to MIL-STD-2411, but further restrict the CADRG [frame file] names to conform to the form "fffffvvp.ccz." (The contiguous frame grid concept is depicted in FIGURE 22.) The "fffff" portion of the name shall be a radix 34 value that encodes the unique cumulative frame number within a zone in base 34, n_{sz} (see equations below), with the right-most digit being the least significant position. (For example, the "fffff" portion of the names would start with "00000," proceed through "00009," "0000Z," "00010," and so forth until "ZZZZZ." The radix 34 value incorporates the numbers 0 through 9 and letters A through Z exclusive of the letters "I" and "O" as they are easily confused with the numbers "1" and "0". This allows 45,435,424 unique [frame file] names; a contiguous grid of frame names down to 1:7800 scale could be defined.) The "vv" portion of the name shall be a radix 34 value that encodes the successive version number. The "p" portion of the name shall be a radix 34 value that designates the producer code ID, as defined in MIL-STD-2411-1. The "cc" and "z" portions of the name extension shall encode the map or chart type and the zone, respectively, as defined in MIL-STD-2411-1. The CADRG producers are responsible to ensure that [frame files] for all map types, scales, zones, and revisions, have unique names.

The number of rows and columns for several scales are provided in TABLES 8 thru 14. The relationships between frame row and column numbers, and the cumulative count of frames within a zone are expressed in the equations below:

$$n_{sz} = c_{Fz} + (r_{Fz} * C_z) \tag{27}$$

$$n_{sz}\ (\text{maximum}) = (R_z * C_z) - 1 \tag{28}$$

$$r_{Fz} = \text{INT}\left\{ \frac{n_{sz}}{C_z} \right\} \tag{29}$$

$$c_{Fz} = n_{sz} - (r_{Fz} * C_z) \tag{30}$$

Where C_z is the number of columns in the zone and R_z is the number of rows in the zone. The frame number of the frame denoted by the frame row r_{Fz} and frame column c_{Fz} is n_{sz}.

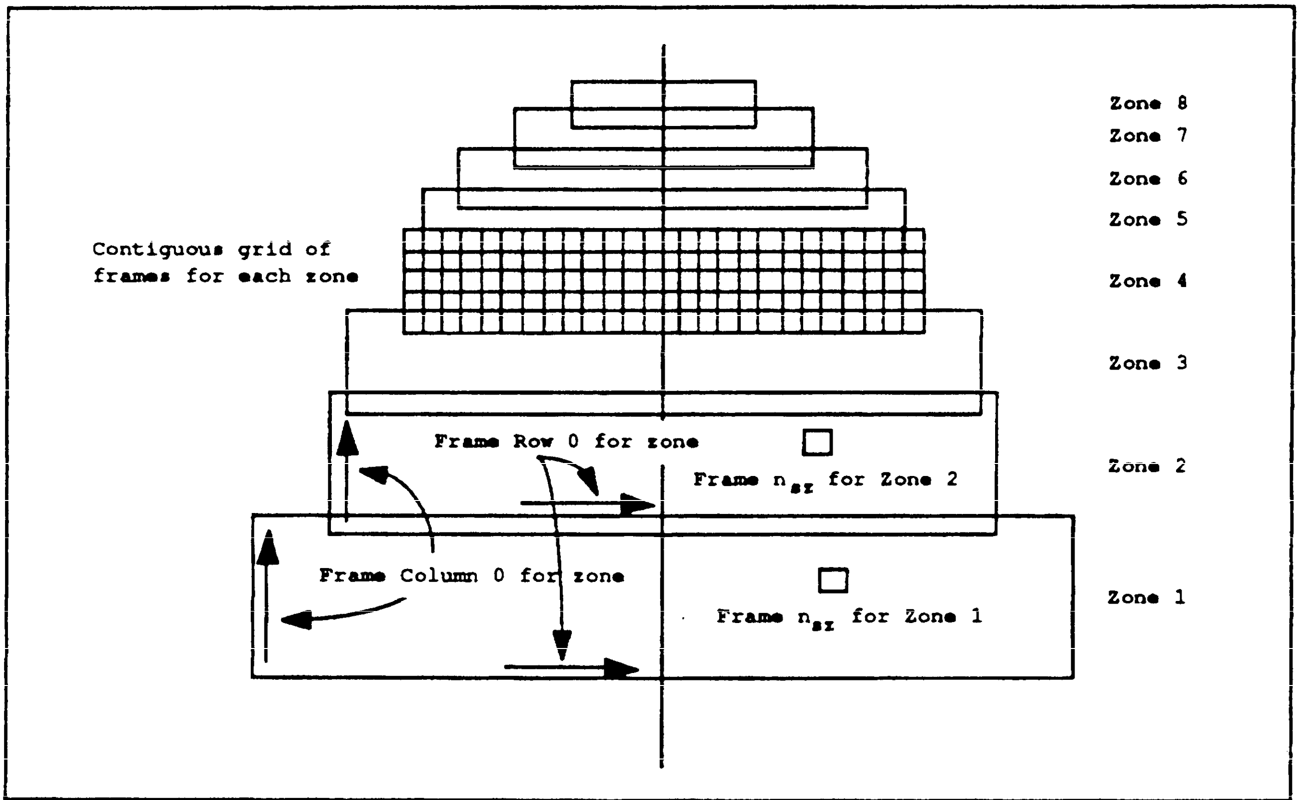

FIGURE 22. Contiguous Frame Numbering Convention for Zones.

40. STORAGE REQUIREMENTS

40.1 Computation of [frame file] size. TABLE 5 provides the sizes of the logical sections in a CADRG [frame file]. TABLE 6 provides typical sizes, based on assumptions about the nature of the data. These assumptions are not mandatory. The percent of total size for the typical section sizes are also provided in TABLE 6.

TABLE 5. CADRG [frame file] Size Computations.

Section Name	Computation of Size
[header section]	Bytes = 48
[location section]	Bytes = 6 + 14 * <number of section/component location records>
[coverage section]	Bytes = 96
[compression section]	Bytes = 74 + 4 * 16384 [compression lookup table] = 65610
[color/grayscale section]	Bytes = 32 + 4 * 217 [color/grayscale table] + 4 * 216 [histogram table] = 1764
[image section]	Bytes = 33 + 72 per [block mask table] + 72 per [transparency mask table] + 221184 [subframe table] (full frame)
[attribute section]	Bytes = variable, depending on <number of attribute offset records>, size of attribute parameters, and the <number of explicit areal coverages>
[replace/update section]	Bytes = 4 + 25 * <number of replace/update records>

TABLE 6. CADRG [frame file] Typical Sizes.

Section Name	Full Frame Example Bytes (% of Total)		Partial Frame Example Bytes (% of Total)	
[header section]	52	(< 0.1 %)	52	(< 0.1 %)
[location section]	286	(~ 0.1 %)	286	(~ 0.1 %)
[coverage section]	96	(< 0.1 %)	96	(< 0.1 %)
[compression section]	65610	(~ 23 %)	65610	(~ 26 %)
[color/grayscale section]	1764	(< 1 %)	1764	(< 1 %)
[image section]	221217	(~ 76 %)	184497	(~ 73 %)
[attribute section]	~400	(< 0.2 %)	~400	(< 0.2 %)
[replace/update section]	29	(< 0.1 %)	29	(< 0.1 %)
Total	289454		252748	

50. CADRG ATTRIBUTE DATA

50.1 CADRG attribute and parameter table. TABLE 7 lists the ancillary attributes and parameters that are included with the CADRG data. Use of parameters facilitates a grouping of related attributes that users would normally need as a group. The <attribute id> and <parameter id> values are defined in MIL-STD-2411-1 ("data dictionary" supplement to MIL-STD-2411).

TABLE 7. CADRG Attributes and Parameters.

Attribute Description	Attr ID	Parameter Description	Parm ID	Data Type
Currency Date	1	Currency Date	1	asci:8
Production Date	2	Production Date	1	asci:8
Significant Date	3	Significant Date	1	asci:8
Map/Chart Source	4	Data Series Designation	1	asci:10
	4	Map Series designation	2	asci:8
	4	Old Horizontal Datum Code	3	asci:4
	4	Edition Identifier	4	asci:7
Projection System	5	Projection Code	1	asci:2
	5	Parameter A	2	real:4
	5	Parameter B	3	real:4
	5	Parameter C	4	real:4
	5	Parameter D	5	real:4
Vertical Datum	6	Vertical Datum Code	1	asci:4
Vertical Absolute Accuracy	8	Vertical Absolute Accuracy	1	uint:4
	8	Accuracy Units of Measure	2	uint:2
Horizontal Absolute Accuracy	9	Horizontal Absolute Accuracy	1	uint:4
	9	Accuracy Units of Measure	2	unit:2

TABLE 7. CADRG Attributes and Parameters (continued).

Attribute Description	Attr ID	Parameter Description	Parm ID	Data Type
Vertical Relative Accuracy	10	Vertical Relative Accuracy	1	uint:4
	10	Accuracy Units of Measure	2	uint:2
Horizontal Relative Accuracy	11	Horizontal Relative Accuracy	1	uint:4
	11	Accuracy Units of Measure	2	uint:2
Ellipsoid	12	Ellipsoid Code	1	asci:3
Sounding Datum	13	Sounding Datum Code	1	asci:4
Navigation System	14	Navigation Systems Code	1	uint:2
Grid	15	Grid Code	1	asci:2
Easterly Annual Magnetic Change	16	Easterly Annual Magnetic Change	1	real:4
	16	Units of Magnetic Change	2	uint:2
Westerly Annual Magnetic Change	17	Westerly Annual Magnetic Change	1	real:4
	17	Units of Magnetic Change	2	uint:2
Grid North-Magnetic North Angle	18	Grid North-Magnetic North Angle	1	real:4
	18	Units of Angle	2	uint:2
Grid Convergence Angle	19	Grid Convergence Angle	1	real:4
	19	Units of Angle	2	uint:2
Maximum Elevation	20	Maximum Elevation	1	real:8

TABLE 7. CADRG Attributes and Parameters (concluded).

Attribute Description	Attr ID	Parameter Description	Parm ID	Data Type
	20	Units of Elevation	2	uint:2
	20	Latitude of Elevation	3	real:8
	20	Longitude of Elevation	4	real:8
Multiple Legend Names	21	Legend File Name	1	asci:12

60. FRAME AND SUBFRAME STRUCTURE

60.1 Method of computation for non-polar zones. This appendix describes the method of computation of the non-polar latitudinal and longitudinal pixel constants and pixel sizes, the number of frames and subframes in each zone for the latitudinal and longitudinal directions, the rules of zone overlaps and the zonal extents. Non-polar CADRG frames shall be north-up. The pixel resolution values (degrees) for the latitudinal and longitudinal directions shall be based, respectively, on the North-South and East-West Pixel Constants. The pixel size and interval data may be used to define [frame file]s containing image data for non-contiguous maps/charts at miscellaneous scales.

60.1.1 North-south pixel constant. The North-South pixel constant is the number of pixels latitudinally from the equator to a pole (90°). The values for CADRG are derived from corresponding ADRG values of the "B" parameter at the 1:1,000,000 scale, listed in APPENDIX 70, TABLE III of MIL-A-89007. The B parameter is first multiplied by a scale factor (1,000,000/S, for 1:S scale maps) and rounded up to the next highest multiple of 512 pixels to determine the pixel constant in ADRG for the other scale. The ADRG value represents 360°, whereas the corresponding CADRG value represents 90°. The CADRG value is determined by dividing the ADRG value by 4 to represent 90°, dividing by the 150µ/100µ spatial downsampling ratio, and rounding to the nearest multiple of 256 pixels (the size of a subframe). The [coverage section] <latitude/vertical interval> (degrees) shall be 90° divided by the North-South Pixel Constant for the scale of the data.

60.1.2 East-west pixel constant. The East-West pixel constant is the number of pixels longitudinally from the 180° west longitude meridian going 360° in an easterly direction along the zone midpoint. The CADRG values are derived from corresponding ADRG values of the "A" parameters at the 1:1,000,000 scale, listed in APPENDIX 70, TABLE III of MIL-A-89007. The A parameters are first multiplied by a scale factor (1,000,000/S, for 1:S scale maps) and rounded up to the next highest multiple of 512 pixels to determine the pixel constants in ADRG for the other scales. The CADRG values are determined by dividing the ADRG value by the 150μ/100μ spatial downsampling ratio, and rounding to the nearest multiple of 256 pixels. The [coverage section] <longitude/horizontal interval> (degrees) shall be 360° divided by the East-West Pixel Constant for the zone of the frame and the scale of the data.

60.1.3 North-south pixel size. The latitudinal pixel size (meters) is derived from the ADRG parameter value at a scale 1:S. The corresponding ADRG value, listed in APPENDIX 70, TABLE III of MIL-A-89007, is derived by dividing the value for the 1:1,000,000 scale by the scale factor (1,000,000/S, for 1:S scale maps). The value for CADRG is derived by multiplying the ADRG pixel size by the ADRG North-South Pixel Constant, and dividing by 4 times the CADRG North-South Pixel Constant. The [coverage section] <north-south/vertical resolution> values (meters) for pixels shall be the North-South Pixel Size.

60.1.4 East-west pixel size. The longitudinal pixel sizes (meters) for each zone are derived from the ADRG parameter values at a scale 1:S. The corresponding ADRG values, listed in APPENDIX 70, TABLE III of MIL-A-89007, are derived by dividing values for the 1:1,000,000 scale by a scale factor (1,000,000/S). The values for CADRG are derived by multiplying ADRG pixel sizes by the ratio of ADRG to CADRG East-West Pixel Constant. The [coverage section] <east-west/horizontal resolution> values (meters) for pixels shall be the East-West Pixel Size.

60.1.5 Equatorward and poleward zone extents.

a. The poleward and equatorward extents of a zone are not exactly equal to the nominal zone extents defined in TABLE 2. Frames overlapping the nominal zone boundaries are filled with data. For the northern hemisphere, the exact poleward zone extent is defined as latitude of the top of the frame overlapping the poleward nominal zone extent. The exact equatorward zone extent is defined as the latitude of the bottom of the frame overlapping the equatorward nominal zone extent. In the case of the southern hemisphere, the top of the overlapping frame defines the equatorward extent, and the bottom defines the poleward extent.

b. To calculate the exact poleward zone extent for a given scale, first calculate the number of pixels in a degree of latitude for the scale. This number is the N-S pixel constant divided by 90° (this number is the inverse of the <latitude/vertical interval> described in 60.1.1). The number of frames needed to reach the nominal zone boundary is the number of pixels per degree of latitude multiplied by the nominal zone boundary (in degrees), divided by 1536, the number of pixels rows in a frame, and rounded up to the nearest integer. The exact zone extent is calculated by multiplying the number of frames by 1536 and dividing by the number of pixels in a degree of latitude.

c. To calculate the exact equatorward zone extent for a given scale, again calculate the number of frames needed to reach the nominal zone boundary (the equatorward boundary in this case) by using the same method described in the previous paragraph. For the equatorward case, round the number of frames down to the nearest integer. Again, the exact zone extent is calculated by multiplying the number of frames by 1536 and dividing by the number of pixels in a degree of latitude.

d. The maximum stretch or shrink of frame pixels within a zone may be computed as the difference between the cosine of the resulting zonal extents latitude and the midpoint latitude, and then dividing by the cosine of the midpoint latitude.

60.1.6 Latitudinal frames and subframes. The number of latitudinal frames and subframes in a zone for a given scale can be computed by using the exact poleward and equatorward zone extents and the number of pixels per degree of latitude (as calculated in 60.1.5). The number of latitudinal frames is the difference (in degrees) between the exact poleward zone extent and exact equatorward zone extent, multiplied by number of pixels per degree, and divided by 1536, the number of pixel rows per frame. Multiplying the number of frame rows by 6 will yield the number of subframes for that scale and zone.

60.1.7 Longitudinal frames and subframes. The number of longitudinal frames and subframes is computed by determining the number of subframes to reach around the earth along a parallel at the zone midpoint. The East-West pixel constant is divided by 256 pixels to determine the number of subframes. The results are divided by 6 and rounded up to obtain the number of frame columns.

60.2 Additional computations for the polar zones. The computations for the polar zones are described in the following sections.

60.2.1 Polar pixel constant. The Polar pixel constant is the number of pixels 360° around a prime meridian. The value for CADRG is derived from the corresponding ADRG value of the "B" parameter at the 1:1,000,000 scale, listed in APPENDIX 70, TABLE III of MIL-A-89007. The B parameter is first multiplied by a scale factor (1,000,000/S, for 1:S scale maps) and rounded up to the next highest multiple of 512 pixels to determine the pixel constant in ADRG for the other scale. (It is important in CADRG that the number of polar pixels be a multiple of two subframes. This is so the number of subframes about the pole can be equal in each direction.) The CADRG value for the polar pixel constant is found by: multiplying the ADRG pixel constant by the ratio 20 degrees/360 degrees; dividing by the 150μ/100μ sampling ratio, rounding to the nearest multiple of 512 pixels, and multiplying by the ratio 360 degrees/20 degrees.

60.2.2 Polar pixel size. The nominal pixel size (meters) for the polar zone is derived from the ADRG parameter values at a scale 1:S. The corresponding ADRG value, listed in APPENDIX 70, TABLE III of MIL-A-89007, is derived by dividing values for the 1:1,000,000 scale by a scale factor (1,000,000/S). The values for CADRG are derived by multiplying ADRG pixel sizes by the ratio of ADRG to CADRG Polar Pixel Constants.

60.2.3 Polar frames and subframes. The number of the polar subframes in each dimension (symmetric) is computed by multiplying the Polar Pixel Constant by the ratio 20°/360°, and then dividing by 256 pixels per subframe. The number of frames is determined by dividing by 6 subframes per frame, but rounding up to the next odd number of frames. (This ensures that a symmetric number of frames can be centered at the pole.)

60.3 Tabular data for frame and subframe structure. Results of computations defined above for the latitudinal and longitudinal data are enumerated in TABLES 8 through 14 for various scales of CADRG source data. The same values can be computed for any arbitrary scale map or chart, using the methodology outlined above in 60.1 and 60.2. This would allow developing CADRG [frame file]s for miscellaneous scale non-contiguous maps/charts.

TABLE 8. Frame/Subframe Sizes for 1:5,000,000 GNC Charts.

N-S Pixel Constant	N-S Pixel Size (m)
13312	754.05

Zone Number	Subframes in Zone (Rows) Latitudinal	Frame Rows in Zone Latitudinal	Equatorward Zone Extent with Overlap	Poleward Zone Extent with Overlap
1,A	24	4	0°	41.5384615
2,B	12	2	31.1538462	51.9230769
3,C	12	2	41.5384615	62.3076923
4,D	12	2	51.9230769	72.6923077
~~5,E~~ *	6	1	62.3076923	72.6923077
~~6,F~~ *	6	1	62.3076923	72.6923077
7,G	12	2	62.3076923	83.0769231
~~8,H~~ *	6	1	72.6923077	83.0769231
9,J	——	——	80°	90°

Zone Number	Subframes (Columns) Longitudinal	Frames (Columns) Longitudinal	E-W Pixel Constant	E-W Pixel Size (m)
1,A	193	33	49408	750.54
2,B	159	27	40704	747.68
3,C	128	22	32768	750.00
4,D	104	18	26624	749.25
~~5,E~~ *	85	15	21760	750.68
~~6,F~~ *	72	12	18432	747.75
7,G	57	10	14592	752.88
~~8,H~~ *	44	8	11264	750.00

Zone Number	Polar (X - Y) Subframes	Polar (X - Y) Frames	POL Pixel Constant	POL Pixel Size (m)
9,J	12	3	55296	726.13

* Not produced due to full frame-level redundancy.

TABLE 9. Frame/Subframe Sizes for 1:2,000,000 JNC Charts.

N-S Pixel Constant	N-S Pixel Size (m)
33280	300.47

Zone Number	Subframes in Zone (Rows) Latitudinal	Frame Rows in Zone Latitudinal	Equatorward Zone Extent with Overlap	Poleward Zone Extent with Overlap
1,A	48	8	0	33.2307692
2,B	30	5	29.0769231	49.8461538
3,C	18	3	45.6923077	58.1538462
4,D	18	3	54.0000000	66.4615385
5,E	12	2	62.3076923	70.6153846
6,F	12	2	66.4615385	74.7692308
7,G	12	2	70.6153846	78.9230769
8,H	12	2	74.7692308	83.0769231
9,J	—	—	80°	90°

Zone Number	Subframes (Columns) Longitudinal	Frames (Columns) Longitudinal	E-W Pixel Constant	E-W Pixel Size (m)
1,A	481	81	123136	299.91
2,B	395	66	101120	299.45
3,C	320	54	81920	300.00
4,D	260	44	66560	299.70
5,E	213	36	54528	299.57
6,F	179	30	45824	298.54
7,G	144	24	36864	299.40
8,H	108	18	27648	300.00

Zone Number	Polar (X - Y) Subframes	Polar (X - Y) Frames	POL Pixel Constant	POL Pixel Size (m)
9,J	30	5	129024	310.00

TABLE 10. Frame/Subframe Sizes for 1:1,000,000 ONC Charts.

N-S Pixel Constant	N-S Pixel Size (m)
66816	149.66

Zone Number	Subframes in Zone (Rows) Latitudinal	Frame Rows in Zone Latitudinal	Equatorward Zone Extent with Overlap	Poleward Zone Extent with Overlap
1,A	96	16	0	33.1034483
2,B	54	9	31.0344828	49.6551724
3,C	30	5	47.5862069	57.9310345
4,D	24	4	55.8620690	64.1379310
5,E	18	3	62.0689655	68.2758621
6,F	18	3	66.2068966	72.4137931
7,G	18	3	70.3448276	76.5517241
8,H	18	3	74.4827586	80.6896552
9,J	—	—	80°	90°

Zone Number	Subframes (Columns) Longitudinal	Frames (Columns) Longitudinal	E-W Pixel Constant	E-W Pixel Size (m)
1,A	963	161	246528	149.80
2,B	788	132	201728	149.85
3,C	640	107	163840	150.00
4,D	519	87	132864	149.75
5,E	425	71	108800	149.67
6,F	357	60	91392	149.69
7,G	287	48	73472	149.53
8,H	215	36	55040	149.77

Zone Number	Polar (X - Y) Subframes	Polar (X - Y) Frames	POL Pixel Constant	POL Pixel Size (m)
9,J	58	11	267264	149.66

TABLE 11. Frame/Subframe Sizes for 1:500,000 TPC Charts.

N-S Pixel Constant	N-S Pixel Size (m)
133376	74.97

Zone Number	Subframes in Zone (Rows) Latitudinal	Frame Rows in Zone Latitudinal	Equatorward Zone Extent with Overlap	Poleward Zone Extent with Overlap
1,A	186	31	0	32.1305182
2,B	102	17	31.0940499	48.7140115
3,C	54	9	47.6775432	57.0057582
4,D	48	8	55.9692898	64.2610365
5,E	30	5	63.2245681	68.4069098
6,F	30	5	67.3704415	72.5527831
7,G	30	5	71.5163148	76.6986564
8,H	30	5	75.6621881	80.8445298
9,J	—	—	80°	90°

Zone Number	Subframes (Columns) Longitudinal	Frames (Columns) Longitudinal	E-W Pixel Constant	E-W Pixel Size (m)
1,A	1925	321	492800	74.94
2,B	1576	263	403456	74.93
3,C	1280	214	327679	75.00
4,D	1037	173	265472	74.95
5,E	851	142	217856	74.75
6,F	715	120	183040	74.74
7,G	573	96	146688	74.89
8,H	429	72	109824	75.06

Zone Number	Polar (X - Y) Subframes	Polar (X - Y) Frames	POL Pixel Constant	POL Pixel Size (m)
9,J	116	21	534528	74.83

TABLE 12. Frame/Subframe Sizes for 1:250,000 JOG Charts.

N-S Pixel Constant	N-S Pixel Size (m)
267008	37.45

Zone Number	Subframes in Zone (Rows) Latitudinal	Frame Rows in Zone Latitudinal	Equatorward Zone Extent with Overlap	Poleward Zone Extent with Overlap
1,A	372	62	0	32.0997124
2,B	192	32	31.5819751	48.1495686
3,C	102	17	47.6318313	56.4333653
4,D	96	16	55.9156280	64.1994247
5,E	54	9	63.6816874	68.3413231
6,F	54	9	67.8235858	72.4832215
7,G	48	8	71.9654842	76.1073826
8,H	54	9	75.5896453	80.2492809
9,J	—	—	80°	90°

Zone Number	Subframes (Columns) Longitudinal	Frames (Columns) Longitudinal	E-W Pixel Constant	E-W Pixel Size (m)
1,A	3851	642	985856	37.46
2,B	3152	526	806912	37.46
3,C	2560	427	655360	37.50
4,D	2075	346	531200	37.46
5,E	1701	284	435456	37.39
6,F	1429	239	365824	37.40
7,G	1147	192	293632	37.41
8,H	859	144	219904	37.49

Zone Number	Polar (X - Y) Subframes	Polar (X - Y) Frames	POL Pixel Constant	POL Pixel Size (m)
9,J	232	39	1069056	37.41

TABLE 13. Frame/Subframe Sizes for 1:100,000 TLM Charts.

N-S Pixel Constant	N-S Pixel Size (m)
667392	14.98

Zone Number	Subframes in Zone (Rows) Latitudinal	Frame Rows in Zone Latitudinal	Equatorward Zone Extent with Overlap	Poleward Zone Extent with Overlap
1,A	930	155	0	32.1058688
2,B	478	78	31.8987342	48.0552359
3,C	240	40	47.8481013	56.1334868
4,D	234	39	55.9263521	64.0046030
5,E	126	21	63.7974684	68.1472957
6,F	120	20	67.9401611	72.0828539
7,G	120	20	71.8757192	76.0184120
8,H	126	21	75.8112773	80.1611047
9,J	—	—	80°	90°

Zone Number	Subframes (Columns) Longitudinal	Frames (Columns) Longitudinal	E-W Pixel Constant	E-W Pixel Size (m)
1,A	9627	1605	2464512	14.98
2,B	7880	1314	2017280	14.99
3,C	6400	1067	1638400	15.00
4,D	5187	865	1327872	14.98
5,E	4253	709	1088768	14.96
6,F	3573	596	914688	14.96
7,G	2867	478	733952	14.97
8,H	2147	358	549632	15.00

Zone Number	Polar (X - Y) Subframes	Polar (X - Y) Frames	POL Pixel Constant	POL Pixel Size (m)
9,J	580	97	2672640	14.97

TABLE 14. Frame/Subframe Sizes for 1:50,000 TLM Charts.

N-S Pixel Constant	N-S Pixel Size (m)
1334528	7.497

Zone Number	Subframes in Zone (Rows) Latitudinal	Frame Rows in Zone Latitudinal	Equatorward Zone Extent with Overlap	Poleward Zone Extent with Overlap
1,A	1854	309	0	32.0084404
2,B	936	156	31.9048533	48.0644542
3,C	468	78	47.9608671	56.0406676
4,D	468	78	55.9370804	64.0168809
5,E	240	40	63.9132937	68.0567811
6,F	240	40	67.9531939	72.0966814
7,G	234	39	71.9930942	76.0329944
8,H	240	40	75.9294073	80.0728947
9,J	—	—	80°	90°

Zone Number	Subframes (Columns) Longitudinal	Frames (Columns) Longitudinal	E-W Pixel Constant	E-W Pixel Size (m)
1,A	19253	3209	4928768	7.49
2,B	15760	2627	4034560	7.49
3,C	12800	2134	3276800	7.50
4,D	10373	1729	2655488	7.49
5,E	8507	1418	2177792	7.48
6,F	7147	1192	1829632	7.48
7,G	5734	956	1467904	7.49
8,H	4293	716	1099008	7.50

Zone Number	Polar (X - Y) Subframes	Polar (X - Y) Frames	POL Pixel Constant	POL Pixel Size (m)
9,J	1158	193	5336064	7.50

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-C-89038	2. DOCUMENT DATE *(YYMMDD)* 6 October 1994

3. DOCUMENT TITLE Military Specification for Compressed ARC Digitized Raster Graphics (CADRG)

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed)*

5. REASON FOR RECOMMENDATION

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